METALLURGIA

The British Journal of Metals

(INCORPORATING THE METALLURGICAL ENGINEER.)

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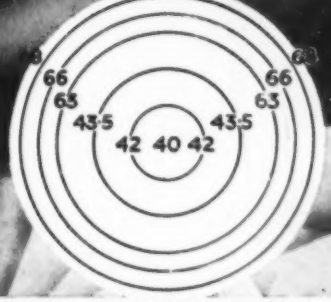

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METALLURGIA

THE BRITISH JOURNAL OF METALS.
INCORPORATING "THE METALLURGICAL ENGINEER".

JANUARY, 1936. VOL. XIII., No. 75.

Progress in Melting and Heat Treatment Furnaces

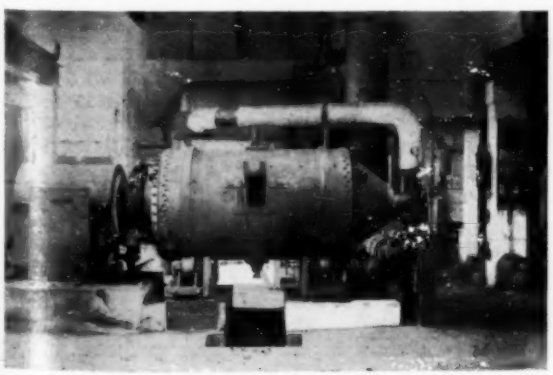
The melting and heat-treatment of metals have developed into a more exacting science than was formerly considered possible. These developments are largely due to progress in metallurgy, and to economical factors which involve control of the application of heat and of furnace atmosphere. In this article some of the more recently constructed furnaces are briefly discussed.

THE demand for better and cheaper products has concentrated attention on melting and heating units, which has resulted in much improved designs and increased efficiency in operation. Many, however, claim that a better quality of product is produced with the old-fashioned and comparatively inefficient coal or coke furnaces, though at a higher cost, than with more modern furnaces heated by oil, gas or electricity. The high quality of work turned out in some works appears to support this view, but if superior work is produced from old furnaces in comparison with those of more modern design, it is the skilled operator rather than the furnace who is achieving such a satisfactory result. Other factors being equal, there can be no doubt that pulverised or gaseous fuels or electricity, which are so closely linked with uniformity of temperature, steadiness of operation, and ease of control, will give better results. The modern furnace, particularly for heat-treatment purposes is designed more on the lines of a machine-tool, and the proper degree of skill is necessary to obtain consistent results.

Melting Furnaces

Of the many melting furnaces installed during 1935, mention may be made of the Brackelsburg furnace, a number of which have been installed for the production of high-duty grey iron, malleable iron, and alloy irons. Several plants are also in use for the production of acid-steel castings. The general characteristics of this furnace are now well known, but it is noteworthy that the smaller sizes have been redesigned to make them suitable for oil or gas firing, as well as pulverised fuel firing for which they were originally designed. Furnaces fired by any of these fuels are available either in the tipping or non-tipping types in capacities from 10 cwts. to 15 tons.

Fig. 2.—Rotary melting furnace of 10 cwts. capacity



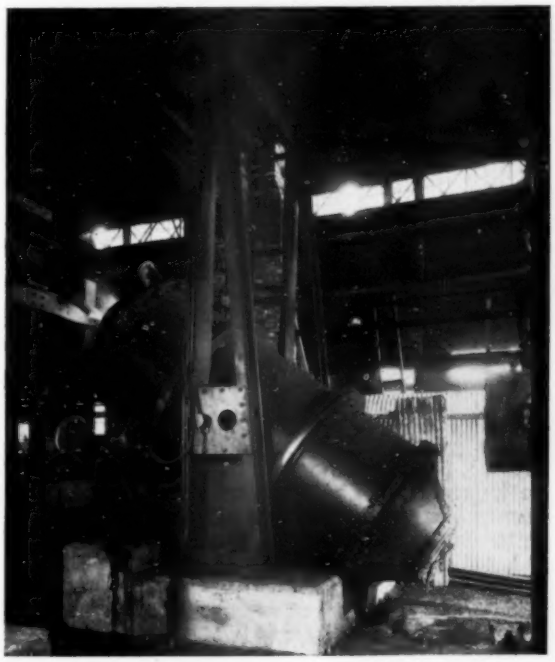


Fig. 1.—Brackelsburg furnace in charging position. The capacity of this furnace is two tons.

The tipping type, shown in Fig. 1, has important advantages as it eliminates charging machine, facilitates patching and relining, affords a clean tap and slag out from every melt, and, in some cases, renders spare barrel and overhead crane unnecessary. The increased use of heat-treatable low-carbon alloy irons is assisting in popularising this type of rotary furnace, since it combines excellent metallurgical control with low operating costs. Several furnaces have been installed for this type of work. An important improvement in operation has resulted from the use of a pulverised fuel burner, designed by H.M. Fuel Research Station, Greenwich, and by the use of the Howden-Ljungstrom high-temperature-type rotary regenerator giving air temperatures up to 600° C.

Another rotary furnace for iron, steel and non-ferrous metals is that by Stein and Atkinson, Ltd. Small oil-fired furnaces of this type are rapidly coming into use to replace other less efficient melting units. They are being used to make high-duty alloy irons and steel castings, all types of bronze, brass and cupro-nickel castings, also for recovering waste materials such as cast-iron borings, copper and brass

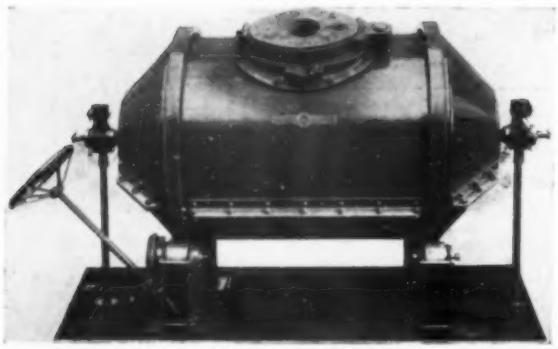


Fig. 3.—Semi-rotary melting furnace by Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., Capacity, 15 cwts. (brass).

Fig. 4.—Aluminium ladling furnace lbs. capacity.

turnings and shear scrap; also for the reduction of lead and copper residues. Special features of this type of furnace are its rapid working, low-fuel consumption and very low-melting loss, in addition mention may be made of the accurate control of the metal. Fig. 2 shows a 10-cwt. capacity unit installed in New Zealand. Although a recent design about 50 of these furnaces have already been installed.

A new range of semi-rotary melting furnaces has been designed by Sir W. G. Armstrong Whitworth and Co., Ltd. Fired by gas or oil, the range embraces the following sizes:—3½, 5, 9, 15, 18 and 20 cwt. (brass capacity), the three larger sizes being fitted with mechanical rotating mechanism, when desired. As will be noted in Fig. 3 the new design incorporates conical ends on the furnace barrel, while the construction of the barrel in halves facilitates relining. In addition to the above range, this firm manufacture several other types of melting furnaces, of which mention may be made of the aluminium ladling furnace, suitable for gas or oil firing. An example of this type of furnace is shown in Fig. 4.

Electric Melting

Reference has previously been made to the Birlec-Detroit rocking-arc melting furnace by Robiette.* This type of furnace, although only recently manufactured in this country, has been in use throughout U.S.A. for many years. Its outstanding characteristics are versatility, rapidity of melting, flexibility, economy in operation, and melting control. This furnace is capable of application to an extremely wide range of melting processes, covering almost all ferrous and non-ferrous metals and alloys. The melting time for almost any type of charge being relatively low.

A useful feature of this furnace is its economical operation, even under intermittent conditions, its design, permitting the melting of entirely different types of charge in consecutive heats in many cases. Further, both radiation losses, electrode consumption and metal losses being reduced to extremely low figures compared with many other types of furnaces, due to the efficient chamber design and the maintenance of a strongly reducing atmosphere above the metal. Low losses and easy regulation of temperature are important factors in facilitating accurate control of the melting operation. Further, the rocking action of the furnace during melting ensures a thorough stirring of the metal and, consequently, strict uniformity of composition throughout the melt. These features make this type of furnace invaluable both in jobbing and production foundries where high-quality castings in various metals and to various specifications may be required or the consistent maintenance of a given standard or quality on an economical basis. A small unit is shown in Fig. 5.

*Metallurgia, February, 1935, pp 101-4

Fig. 5.—Birlec-Detroit rocking arc furnace with a capacity of 1,000 lbs. recently built and installed in this country.

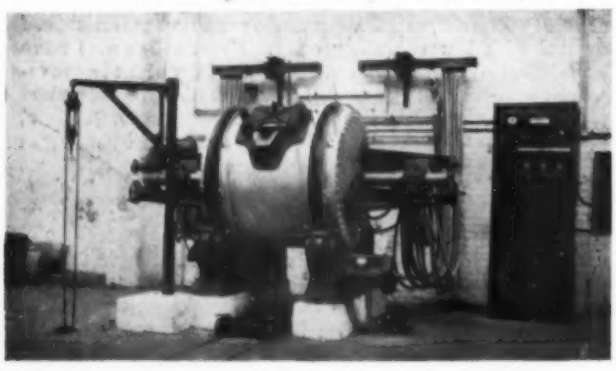


Fig. 6.—A pair of soaking pits installed by Stein and Atkinson, Ltd., at Messrs. Steel, Peech and Tozer, Ltd.

Heating Furnaces

During the past two years Messrs Stein and Atkinson, Ltd., have installed or are now building 18 soaking pits. These are all of the recuperative type as opposed to the older regenerative system, and are fired with this firm's patented pressure burners. These burners are arranged to permit flame development above the ingots, which are thereby kept from contact with unburnt air or gas; the gases take a downward horseshoe path in the furnace chamber, so that the burnt gases sweep over the ingots and maintain a non-oxidising atmosphere.

Soaking pits of this type, which are illustrated in Fig. 6, have a very high output, and show a decided saving in fuel over regenerative pits. The output from a given floor space is practically double. Scale is also reduced to a marked extent, and the quality of heating is claimed to be superior.

Continuous Billet Furnaces

Fig. 7 shows a continuous furnace installed by the Whitehead Iron and Steel Co., Ltd., at their Newport Works, for heating billets 2½ in. × 2½ in. × 30 ft. long, at the rate of 25 tons an hour. These are used in a Morgan continuous strip mill. The company have two other furnaces of the same type. Another continuous furnace,

for billets 7 ft. long, with an output of 12½ tons an hour, installed at Arthur Lee and Sons, Sheffield, is shown in Fig. 8. This furnace has a "Rust" patent soaking zone, in which the billets are given a prolonged soak at constant temperature after leaving the heating chamber and before being discharged.

All these furnaces are fitted with pressure burners and centralised control. They also have Stein suspended roofs in which each individual block is supported separately and has perfect freedom to expand without setting up compression stresses in the roof. They are very economical in fuel, consuming only 130–140 lbs. of coal per ton of steel. Special "conditioning" burners are fitted to control the atmosphere surrounding the billets and to reduce the scale, which are very effective.

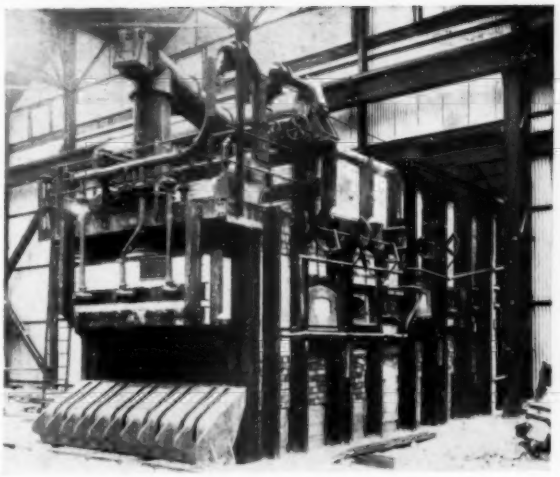


Fig. 8.—A similar type to that shown in Fig. 7, but for longer billets, installed at Arthur Lee and Sons, Sheffield.

Heat-Treatment Furnaces

A very large plate-annealing furnace and charging machine, recently installed at the Motherwell Works of Messrs. Colville, Ltd., is shown in Fig. 9. This furnace, which is the work of Messrs. Stein and Atkinson, Ltd., takes plates measuring 50 ft. by 14 ft. in one piece, or, if desired, the furnace and charging machine may be sub-divided into four parts for dealing with smaller plates. Heating is very even, the maximum temperature difference over the hearth being of the order of ± 5° C.

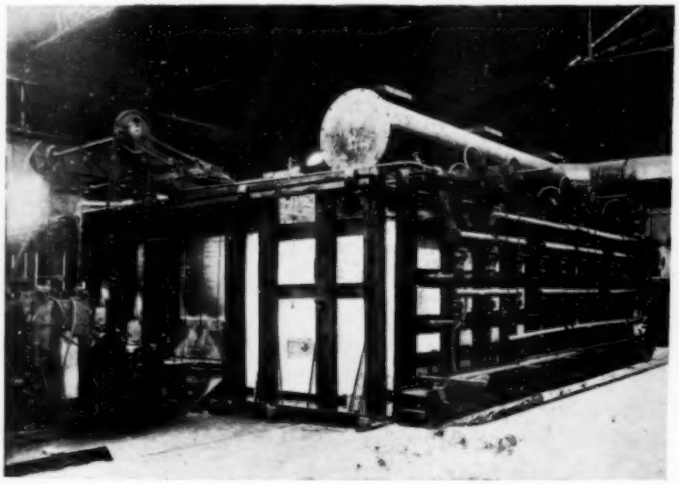


Fig. 7.—A continuous billet heating furnace installed at the Newport Works of the Whitehead Iron and Steel Co., Ltd.

During the past few months Messrs. Brayshaw Furnaces and Tools, Ltd., have made several additions to their series of designs. In the treatment of high-speed and alloy steels, the effect of heating under controlled atmosphere and temperature conditions, has of late been re-investigated, and a considerable measure of success attained in connection with the reduction of scaling and grain growth even at temperatures up to and including 1,380° C. Fig 10 shows a furnace manufactured under licence from the Sheffield Gas Co., for the treatment of these alloys. In common with most H.S.S. furnaces this plant is arranged with heating and preheating chambers, but it will be seen that separately controlled burners are fitted to the top chamber in order that alloy steels requiring temperatures up to say, 1,000° C. can be treated accurately, irrespective of the temperature in the bottom chamber. The patent apparatus for the production of the special atmosphere is shown fitted at the back of the furnace. Furnaces similar in principle, but of a much larger size have been installed with very successful results for the batch treatment of special magnet steels at 1,260° C.

Pit-Type Electric Furnaces

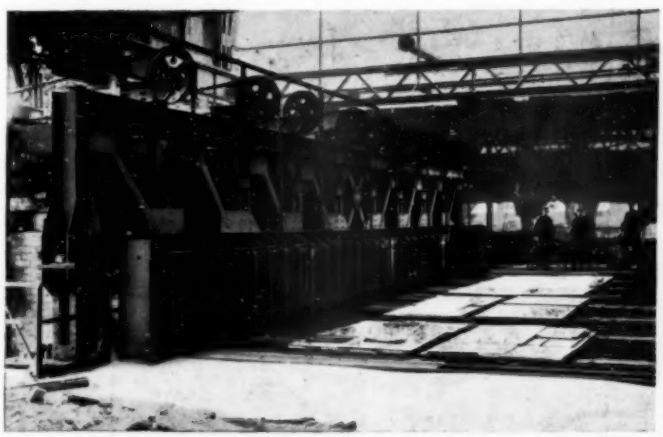
An installation of particular interest, for which Birmingham Electric Furnaces, Ltd. have been responsible, is of the vertical pit type and is, we believe, by far the largest electrically-heated furnace of this kind in the country. It is designed for the heat-treatment of long, hollow forgings and has a number of interesting features.

This furnace, which is shown in Fig. 11, has a chamber 33 ft. deep × 3 ft. 0 in. diameter approximately, and is rated at 430 k.w. It can attain temperatures up to 1,000°C., being fitted with a patented type of heavy cast nickel-chromium alloy grid-type heating elements, divided into no less than eight separately controlled sections from top to bottom of the chamber to ensure uniform heating.

Temperature control, of course, and particularly heat distribution, are points requiring specially careful consideration in a furnace of this shape, but it is gratifying to report that, so successful has been the arrangement adopted in this case, there is no discernible difference in the physical properties of the metal in any part of the charge which has been treated in this equipment while distortion—often difficult to avoid in long forgings, is completely absent.

Furnaces with forced-air circulation are now

Fig. 9.—Large annealing furnace and charging machine by Stein and Atkinson, Ltd., installed at the Motherwell works of Messrs. Colville, Ltd.



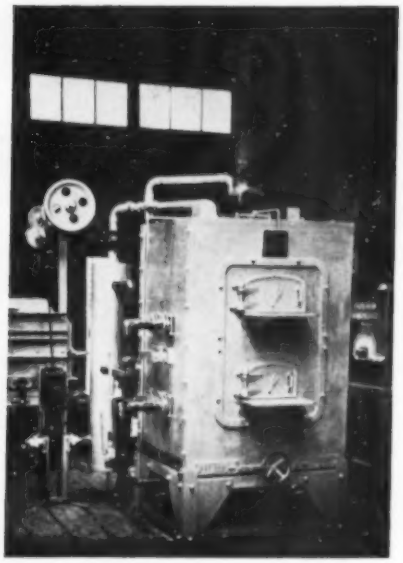


Fig. 10.—High-speed steel furnace manufactured by Messrs. Brayshaw Furnaces and Tools, Ltd., under licence from the Sheffield Gas Co.

quite familiar. A recent development of this type of furnace has been added to the Wild-Barfield range. This furnace holds a retort, inside which are fitted heating elements of nickel-chromium on grooved formers. Inside the elements stands an open-top basket, with perforated bottom. A patented centrifugal fan provides the atmosphere circulation in the retort, which is fitted with entries for a non-oxidising gas supply. Since the fan is fitted inside the retort more rapid heating and better uniformity of the charge is effected. Temperature control is effected automatically, by the charge-progress recorder, which not only controls and records the temperature, but also records when the charge itself has reached the desired temperature. For bright tempering, the charge must cool in the gas atmosphere; to ensure rapid cooling an annular space is left between the heat insulation and the retort, through which air is blown, and to further shorten the cooling time, the fan is left running during this period.

A New Cyanide Furnace

Modern cyanide practice is tending to the use of larger furnaces, and Fig. 12 shows a furnace recently developed

Fig. 11.—Large electric furnace designed for the heat-treatment of long forgings.

Fig. 12.—Large cyanide furnace developed by Cassel Cyanide Co., Ltd.

by Cassel Cyanide Co., Ltd., which takes a pot 24 in. diameter × 21 in. deep. The work capacity of the pot naturally varies with the nature of the work, but an average charge may be regarded as 300 lbs. of steel. It will be noticed that this furnace, which is in regular production, has no hood for the extraction of fume, since fume can be completely prevented by adopting up-to-date methods and chemicals. The furnace was working at 950° C. when the photograph was taken.

Two tangential oil burners are fitted to this model, the maximum consumption of each being two gallons per hour of 70 seconds fuel oil. When working temperature is attained the fuel consumption is reduced to ¾-gallon per burner per hour.

(To be continued.)

Recent Developments in Alloy Steels

A very informative lecture on alloy steels was given by Mr. J. H. G. Monypenny at a well-attended meeting of the Manchester Metallurgical Society recently. Considering first the low alloy steels, he pointed out that there is an increasing demand for cheaper steels possessing really good mechanical properties. This has been met by such alloy combinations as manganese and molybdenum, chromium and molybdenum together in suitable amounts, but with a low total alloy content rarely exceeding 2½%. Suitable combinations of these alloys have enabled steel makers to offer steels of high tensile strength—up to about 65–70 tons per sq. in.—and toughness. Continuing, he discussed highly stressed bolts of high tensile strength, and stated that chromium-molybdenum steels are preferred by many engineers to the nickel-chromium-molybdenum type for bolts exposed to high-steam temperatures.

Of the more highly alloyed steels, Mr. Monypenny stated that the corrosion- and heat-resisting types were being used in increasing quantities. There has been definite improvement in the qualities produced, and they are being processed with greater ease than at one time seemed possible He commented on the quality of the surface finish of sheets and mentioned particularly a brand of austenitic steel of the weld-decay-free type which is available in sheets possessing a highly-polished surface. He discussed very low carbon alloy and mentioned the difficulty in reducing carbon below 0·1%. Among recent developments he referred to patents taken out in America and Germany for steels in which the principal alloying element is phosphorus; this element being used up to 2%. A number of slides were shown to support the statements made, one, in particular, being noteworthy; this gave comparative costs of steels, together with their important mechanical properties. Considerable discussion followed the lecture, and it was stated to be one of the most interesting evenings held by the Society.

METALLURGIA
THE BRITISH JOURNAL OF METALS.
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WORK AND RESEARCH

WHEN men return to their job, the cycle of production distribution, and consumption makes headway, because the producer is also the consumer. It is this fact that has contributed to recovery in British industry, which is indicated by the improvement in the production figures so far available for 1935. The average for all departments of British trade, during the first nine months of the year, was 11·8% greater than during the same period in 1930, as against 4·5% in 1934. This higher figure is largely accounted for by the abnormally high output of the building and non-ferrous metal industries which show improvement to the extent of 48·3 and 39·1% respectively. Since the peak year of unemployment, when nearly 3,000,000 were idle because of the depression, there has been a gradual reduction by over 1,000,000, and now the number of unemployed is appreciably below 2,000,000. But the significance of this improvement is only appreciated when it is recognised that at the end of November 10,500,000 were in employment—a record since the figures were first compiled. This improvement is having a cumulative effect and, with the gradual recovery of world trade, is giving confidence to industry, enabling it to continue reorganisation schemes for the further development of particular sections.

There has been steady expansion in engineering output in the past year. Motor works are more prosperous than ever, and it is noteworthy that a considerable measure of success has been achieved in the export market. In machine tool manufacture, a gradually growing demand is providing a welcome stimulus. Electrical engineering has benefited from improved conditions, particularly as a result of new installations following the reorganisation of a number of industries, but railway demands have also been substantial, while large contracts should result when the State guarantees for the new railway loans are completed. The aircraft industry is progressing, and in addition to having a good number of orders on hand, may look forward to a much wider extension because of the demands of the Government and also to the development of aircraft for commercial work. It must be remembered that aircraft manufacturers in this country are at a disadvantage in comparison with American and Continental manufacturers, but the future for this industry is decidedly promising.

In the basic industries there is greater optimism and the fact that this has sounder grounds than for many years past makes the outlook more reassuring. At the time of writing it looks as though an amicable settlement will be achieved in the coal industry, in which case industrial peace, which has been enjoyed for nearly nine years, will not be interrupted. This industry has recently shown a considerable measure of recuperation, and it would be a mistake to provoke of conflict of interests at a time when there is reasonable hope for recovery. It is to be hoped, therefore, that wise councils will prevail and enable work to proceed on terms agreeable to both miners and owners. With regard to the textile trade, historians may regard 1935 as the turning point towards progress and prosperity; not since 1929 has such a good year been experienced, and this improvement is influencing the installation of new machines long overdue in consequence of the depression. This trade shows distinct promise of increased work and manufacturers are more hopeful than for some years.

Probably the most progressive industry is the iron and steel industry. During this last year it seems to have developed new activity and to have definitely recovered itself. Production of both pig iron and steel has expanded, but the expansion has been more marked in steel than pig iron. In steel it is probable that the 1929 record will be surpassed. Probably the most important feature of the year was the agreement with the members of the Continental Steel Cartel, the signing of which gave the British industry recognition in the councils of Europe in matters concerning steel production. There has been improvement in the export of steel, but the amount is still far short of that desired. There is a tendency for iron ore, coke and scrap to increase in price, which may result in the advance of steel prices, such a step is not likely to be taken unless current prices are economically unsound. Here again the prospects for this year are remarkably good. An important factor in support of a continuance of improved conditions in the steel trade is the recovery shown in shipbuilding. A substantial number of orders has been placed recently for tankers and cargo boats and these, together with the promised British naval orders, have brightened the prospects of work during this year.

Although it is true that improved world conditions are mainly responsible for increasing the amount of work to be done, much of the success achieved in this country is due to extensive research, which has been carried out with unabated vigour during the years of depression. In view of the success achieved from research it is not difficult to answer the question occasionally asked—does research pay for itself? It is only necessary to consider the widespread use of many inventions based on research to answer this question. An enumeration of the industries that have grown up in the last decade also recalls those which have been supported by research. The increase in the number of research laboratories in the chemical, electrical, metallurgical, textile and other industries also testify that research pays. During the last few years particularly, there has been intensive research and development in the use of metals.

It may be as well to point out the difference between invention and research. An invention is the application of known facts and principles in a new way. Research, on the other hand, is the search for new facts and principles which may subsequently be used in inventions. Inventions are possible without research, but almost invariably, invention must wait on research It can be said with considerable truth that research is the most effective weapon in the present warfare of industrial competition, and it is becoming more and more essential to hold old markets and create new ones.

It is not necessary to give examples of research which have contributed to progress and assisted in providing work, as readers will be familiar with many, but research is not concerned only with chemistry and physics, it may be purely mathematical, such as the determination by statistical analysis of the relationships between wages, working time and production, from which new facts and principles may be brought to light. New fields of research are frequently presented, and an important task of the future, worthy of intensive research, is to obtain facts and principles which can be applied to control the forces of the economic cycle, so that the jobs to which men are returning will be more regular.

Correspondence

Electric Resistance Alloys

The Editor, METALLURGIA

Sir,—I have to thank Mr. Peters for his letter published in your December issue. In it he works up a most ingenious defence for nickel chromium type alloys against the Kanthal type.

Mr. Peters admits that " Kanthal alloys are superior in oxidation resistance to nickel chromium at any temperature." I am prepared to admit that Kanthal alloys are not so strong as nickel-chromium alloys at high temperatures (at any rate, at those temperatures at which Mr. Peters' tests have been conducted). Here lies the cause of the apparent inferior results Mr. Peters has obtained on Kanthal.

The A.S.T.M. test (commonly known here as the Bash and Harsch test) uses a vertical wire, and, to enable this wire to be held vertical, a weight or tension is attached at the bottom. The size of this tension has no other particular significance, and it was carefully determined to be suitable for the diameter of the wire employed. Bash and Harsch knew that if the tension be too large the wire will stretch and the resistance of the wire increase because of this tension, and not because of the oxidation which takes place under the heat of the test. It should be remembered however, that Bash and Harsch developed their test for nickel-chromium alloys as these were the only ones known at the time. I am certain that if Kanthal alloys had been known, and had been the basis of the test, a different tension would have been applied. This tension would have been smaller because of Kanthal's tensile properties at the temperature of the test (1,065° C.) standardised by Bash and Harsch. Thus the reason that, under the A.S.T.M. test, Kanthal shows a higher increase of resistance during the early period of the test is the tension stretches it causing its cross section to decrease. This resistance increase is due to the tension and not to oxidation. In effect, the A.S.T.M. test has become a creep-stress test not an oxidation resistance test.

Let Mr. Peters take away this tension, or alternatively attach the bottom end firmly to a fixed point, and a very different story will be told. Actually, as Mr. Peters says, the Kanthal works employ the A.S.T.M. test, but discard the tension—hence their better results with Kanthal than nickel-chromium. Mr. Nordstoem's comparison cited by Mr. Peters, employed nickel chromium wire of the very latest high standard, for Kanthal too has improved since you published my article in your Journal in 1932. It is significant that on Mr. Peters' own tests, the materials which had not failed when his tests were stopped are Kanthal, in spite of the handicap of the tension.

The Bash and Harsch test may be regarded as standard in America, but in this country it has not found favour. In this country we prefer tests more near to actual use. They take longer but are better. Let Mr. Peters make up elements, one with nickel chromium and the other with Kanthal D. In both instances use the same normal size of wire, employ the same loading, and take suitable precautions to support the Kanthal element. Then, put them on test in ordinary everyday use, or, if wished, accelerate their life by frequent switching on and off. I am certain that the Kanthal element will maintain its loading better than any nickel-chromium alloy (even those of to-day's best—English or American). The success of Kanthal for rod-type elements, which are very much in favour in England, is sufficient proof of its reliability. Other very favourite applications are, grill boiler plates and flat-bar fires

Kanthal alloys are admittedly better heat resistors, and any inferior mechanical properties can be overcome—in fact, have been overcome in this country—by good design. The sales in this country are ample proof of this, and Kanthal is being used successfully in large quantities in many other European countries. Mr. Peters' results depend on a test which at the best is useful only in comparing nickel-chromium alloys with each other. In England we even disagree on the suitability of the A.S.T.M. test for comparing nickel-chromium alloys.

I do not propose to attempt to enumerate other advantages in Kanthal alloys, but I would like to say I have been happy to make Mr. Peters' acquaintance in the columns of your Journal. I am sure, if we ever meet in the flesh, we shall have much in common to talk about.

Yours faithfully,

J. H. RUSSELL, Works Manager.
Hall and Pickles, Ltd.

Forthcoming Meetings

INSTITUTION OF MECHANICAL ENGINEERS

Jan. 24. " Exhaust Turbines for Marine Propulsion with Special Reference to the Rowan-Gütaverken System," by J. B. O. Sneeden, Ph.D., B.Sc., A.M.I.Mech.E.

Jan 31. " Service Maintenance of High-Speed Internal Combustion Engines for Transport and Power," by E. C. Ottaway.

Feb. 7. " The Training of Craftsmen," by F. E. Robinson, M.I.Mech.E.

INSTITUTE OF METALS

BIRMINGHAM SECTION

Jan. 30. " The Polishing of Metals," by E. J. Dobbs.

LONDON SECTION

Feb. 6. " The Application of Metals in Chemical Engineering," by H. W. Cremer, M.Sc.

NORTH EAST COAST SECTION

Feb. 11. " Some Recent Developments in the Improvement of Non-Ferrous Alloys by Heat-Treatment," by W. T. Griffiths, M.Sc.

SCOTTISH SECTION

Feb. 10. " Corrosion of Metals by Industrial Waters," by F. Hudson.

SHEFFIELD SECTION

Feb. 14. " Engine Turning and Enamelling," by R. S. Hill.

SWANSEA SECTION

Feb. 11. " Some Modern Developments in Stainless Steels," by J. H. G. Monypenny.

MANCHESTER METALLURGICAL SOCIETY

Feb. 5. " Trends of Metallurgical Developments," by Major F. A. Freeth, O.B.E., Ph.D., D.Sc., F.R.S.

N.E. COAST INSTITUTION OF ENGINEERSAND SHIPBUILDERS

Jan. 24. " The Protection of Ships Hulls against Marine Corrosion," by William E. Lewis, B.Sc.

Feb. 7. " Friction of Piston Rings," by Eng. Comr. C. J. Hawkes, R.N. (ret.), and G. F. Hardy, M.Sc.

INSTITUTE OF BRITISH FOUNDRYMEN

BIRMINGHAM BRANCH

Feb. 7. " Modern Core Shop Production," by W. H. Smith.

EAST MIDLANDS BRANCH

Feb. 1. " A Preliminary Report on Moulding Costs by the Costing Sub-Committee of the Technical Committee."

LINCOLNSHIRE SECTION

Feb. 8. " Soundness and Fluidity in Cast Iron," by H. Bunting.

LANCASHIRE BRANCH

Feb. 15. " Alloy Cast Irons," by P. A. Russell.

BURNLEY SECTION

Feb. 11. " Patternmaking—The Craftsman and his Craft," by H. Stead.

PRESTON SECTION

Feb. 12. " Materials and Processes used in the Production of Internal Combustion Engine Castings," by A. L. Key.

LONDON BRANCH

Feb. 5. " How to Reduce Core-making Costs " by N. P. Newman.

NEWCASTLE-ON-TYNE BRANCH

Jan. 25. " The Technique of Chilling," by J. Roxburgh.

SCOTTISH BRANCH

Feb. 8. " A Plea for Loam Moulding," by R. Liddle.

WALES AND MONMOUTH BRANCH

Jan. 24. " The Use of Sodium Carbonate in Iron and Steel Works," by N. L. Evans.

Feb. 14. " The Heat Treatment of Steel Castings," by Prof. W. R. D. Jones, D.Sc.

WEST RIDING OF YORKSHIRE BRANCH

Feb. 8. A Preliminary Report on Moulding Costs by the Costing Sub-Committee.

Modern Developments in Cold Rolling Mills

In the limited scope of these notes the author has confined his consideration to a general review of up-to-date mill designs, with reference to representative examples of mills which have fulfilled present-day requirement in cold-rolled strip and sheet production, and also to show the possibility of further development towards ever greater efficiency, without any revolutionary change in basic design.

By
C. E. DAVIES,
A.M.I.MECH.E.

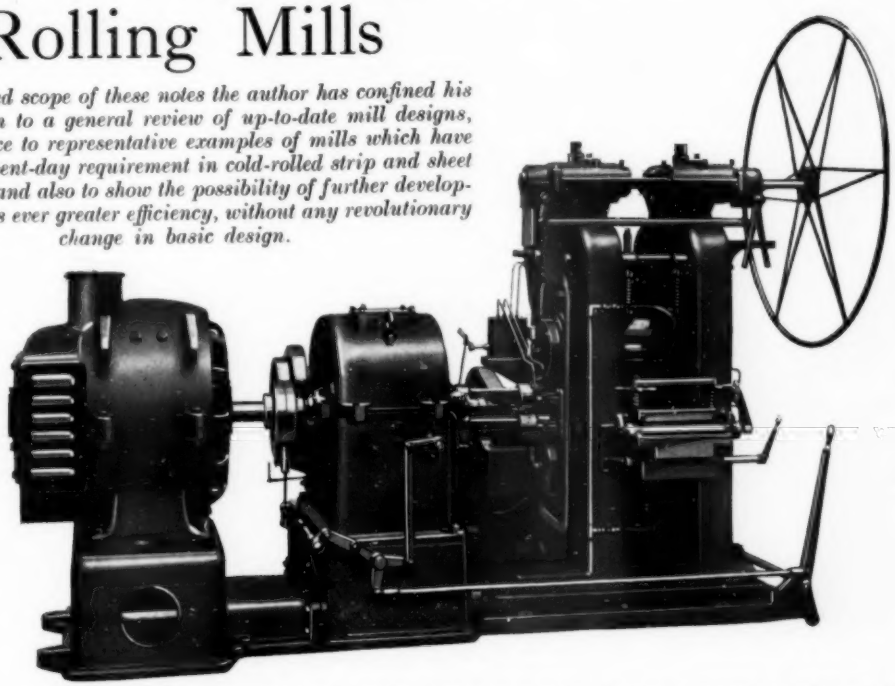


Fig. 1.—Four-high cold strip mill for non-ferrous metals.

DURING the past three or four years the present writer has on several occasions endeavoured to review the trend of cold-rolling mill design. In this period, which might be extended to cover the last seven years, owing to the rapid development of cold-rolling mills of various new and improved types, it has been extremely difficult to express any very definite opinion on the relative advantages of the several designs which have been, to some extent, on trial. Now, following practical experience, opinion has crystallised in regard to the main features of economical successful cold-rolling plant.

Cold-rolling mills may be classified under two main heads :—

(1) Mills for non-ferrous metals and alloys, of which the most important are copper, brass, nickel silver and aluminium.

(2) Mills for steel, including those for both low and high qualities with also special alloy steels.

Both these classes must be subdivided into mills for sheet and strip, owing to the fact that the present tendency in sheet-mill design diverges to some extent from that in strip mills. A sheet mill, for the purpose of this classification, can be defined as a mill rolling relatively wide metal in shorter lengths, generally not exceeding three times the width.

These two classes are becoming merged in the strip-sheet mills already developed so extensively in the States and in which wide sheets are produced by rolling metals in heavy coils, which are afterwards flattened and cut to sheet dimensions. The economy of this method, requiring as it does an extremely large capital outlay depends entirely on a sufficient output to carry the consequent heavy overhead charges. Although, as indicated above, the most economical mill for non-ferrous metals may differ from that for steel, there are certain main principles of modern practice which are common to both.

Rolling Speed.—Within the writer's experience (covering some twenty-five years) cold-rolling speeds have increased from about 60 ft. per min. to 300 ft. per min., and whilst progress in this direction has suffered checks, it can now be definitely stated that high speeds are now the general rule rather than the exception, and although for certain special work lower speeds may be still preferred, it is now *extremely rare* to find *mills installed during recent years to be running at less than* 150 *ft. per min.* Even the most delicate cold-rolling process, that of the production of metal foil, rolling speeds of 250 ft. per min. and higher are now proved successful.

High rolling speeds have been rendered economically possible solely by the better understanding of the mechanics of the rolling mill and the resulting improvement in detail design, particularly in the improved efficiency of the *roll bearings*. But for the development of large roller bearings and their application to the rolling mill, and the introduction of the " Flood " lubrication roll bearing in 1928, it is safe to say that the high rolling speeds now so general would not be economically possible.

Heavy Reduction per Pass.—All modern mills are designed to be capable of effecting the maximum reduction in the thickness of the metal as is economically possible ; in the case of non-ferrous metals, in strip, reductions of 40–45% of the initial thickness are not uncommon. Such heavy reductions are effected at the high rolling speeds mentioned above, and the opinion frequently expressed in the past that high speeds necessarily implied light reduction is certainly proved incorrect if applied to the cold-rolling mill of to-day.

Actually the reduction obtained in any pass is limited, first, by the practicability of entering the strip between the rolls, and secondly by the power provided for driving the mill. Frequently also the amount of reduction, particularly in the finishing passes, is controlled by other considerations, such as finish, accuracy and temperature desired.

In this connection, it should be noted that variation of the temperature of the rolls themselves is a serious factor to be considered in the rolling of strip metals, and that the *rise of roll temperature*, due to the work done in deforming the metal, increases with the *reduction per pass*, is *not appreciably affected by the rolling speed*. The only effect of increased speed is that the maximum roll temperature is reached more quickly. There is also another limitation of reduction in rolling, namely, the capacity of the rolls themselves, now practically always of hardened steel, to withstand the severe stresses imposed on the roll material by heavy reductions without excessive wear and resulting short useful life.

Steel-roll makers appear to have reached the maximum

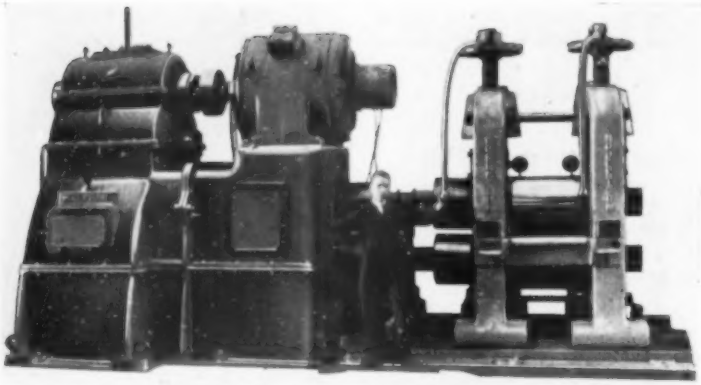


Fig. 2.—Cold-breaking-down mill for brass strip.

hardness and rigidity in the chrome-alloy steels usually employed for cold rolls, and at present the ultimate capacity of a mill is limited in practice by the resistance of the rolls themselves rather than the reducing power of the mill. A recent development has been the production of heat-treated Alloy Cast Iron Rolls, which are made to give a hardness of 90–95° (equivalent to the average hardness for steel rolls), but as yet experience with such rolls has not been sufficient to permit any definite expression of opinion on their value as a substitute, in any class of rolling, for the hardened-steel roll.

Cold-Strip Mills for Non-Ferrous Metals.—For the greater part of strip rolling in copper, brass, etc., *the two-high mill* running at a high speed seems to be firmly established as the most economical type, with the following exceptions :

(*a*) The rolling of extremely thin strip, between 0·01 and 0·001 in. thick, where the four-high mill with small working rolls has proved to be most efficient, particularly when dealing with harder metals and alloys, and for softer metals where the finished gauge is of the order of 0·001 in. thick and thinner. Copper foil, for example, has been rolled down to 0·0005 in. thick in four-high mills.

(*b*) The rolling of wide strip where the four-high mill has also proved its value, particularly in the "getting-down" stage. In finishing wide strip the two-high mill still shows to advantage. It is difficult to draw a line on the scale of widths where it becomes economically advantageous to employ the four-high in preference to the two-high, as this depends on other factors, such as the hardness of the metal rolled, etc. But roughly, when the strip width exceeds 16 in., most certainly when above 24 in. wide, the four-high shows a definitely greater reducing power Such a mill is shown in Fig. 1 ; it has working rolls 5 in. diameter, and supporting rolls 12 in. diameter, and this mill has proved most efficient in producing copper, brass and bronze strip to extremely light gauges (0·001 to 0·0005 in. thick).

A modern brass-strip mill for moderate width (average width say 12 in.), consists of relatively few independently motor-driven mills, each capable of effecting maximum reductions, and the highest economical speeds in relation to the output required for each unit to give a balanced production, and would include a breaking-down mill, intermediate mills and finishing mills. The general tendency is to employ rolls of rather larger diameter than was common in the past, and even with narrow strip finishing mills a 10 in. diameter roll with 12 in., 14 in. and even 16 in. diameter rolls for wider strip, are now accepted as good practice.

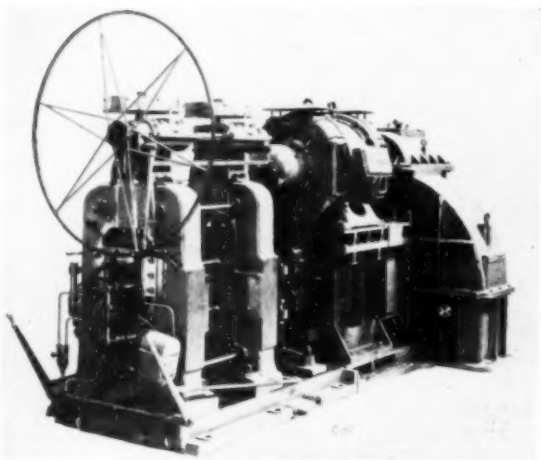


Fig. 4.—Finishing mill for brass strip.

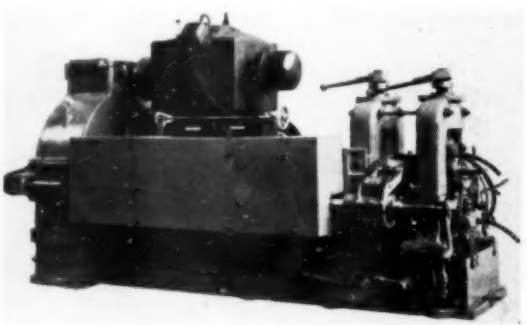
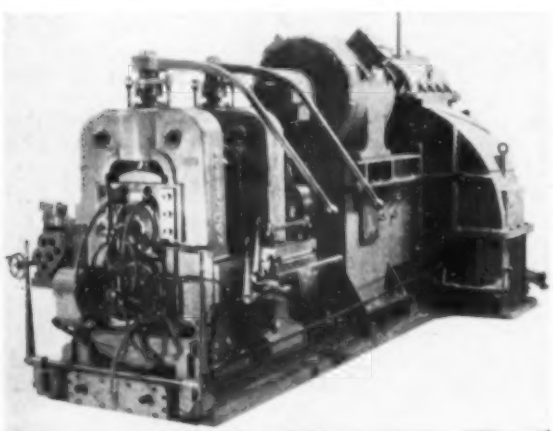


Fig. 5.—Finishing mill of similar type as in Fig. 4, fitted with automatic coiler.

Fig. 3.—High speed intermediate mill with automatic coiler.



Some examples of recent brass-strip mills are illustrated in Figs. 2, 3, 4 and 5. Fig. 2 shows a cold-breaking-down mill, with enclosed gearing, driven by a superimposed motor of 250 h.p., the rolls are 20 in. diameter, and the rolling speed 75 ft. per min. Motor-driven high-speed intermediate and finishing mills, with rolls 16 in. diameter, are shown in Figs. 3 and 4. The rolling speed is 200 ft. per min. The mill in Fig. 3 is equipped with automatic roll-type coiler, mounted on hinged bracket, capable of coiling strip from ¼ in. thick down to 0·040 in. thick, without handling between rolls and coiler. Finishing mills for thin strip of the same type is represented by Fig. 5. This is fitted with rolls 10 in. diameter, and is designed to run at 300 ft. per min. It is driven by a motor of 80 h.p., and is provided with a "Tormanco" automatic coiler, with friction clutch to regulate tension and pedal-operated clutches for stopping, starting and reversing (this latter to free coil from drum.)

Whilst some of these mills, as in Fig 3, have separate

spanner-roll adjustment, as preferred by users, it is now becoming more general to fit powerful screw-down motion operated by large handwheel through enclosed worm gearing, with clutches to provide for independent adjustment of each screw. All the high-speed mills illustrated have their rolls mounted in patent "Flood" lubrication bearings (of which Messrs. W. H. A. Robertson and Co., Ltd., are the sole manufacturers). The general design in which the motor is mounted above the gearing is becoming increasingly popular owing to the great economy in floor space obtained, providing clear working space all round the mill. The objection sometimes raised to the design, is

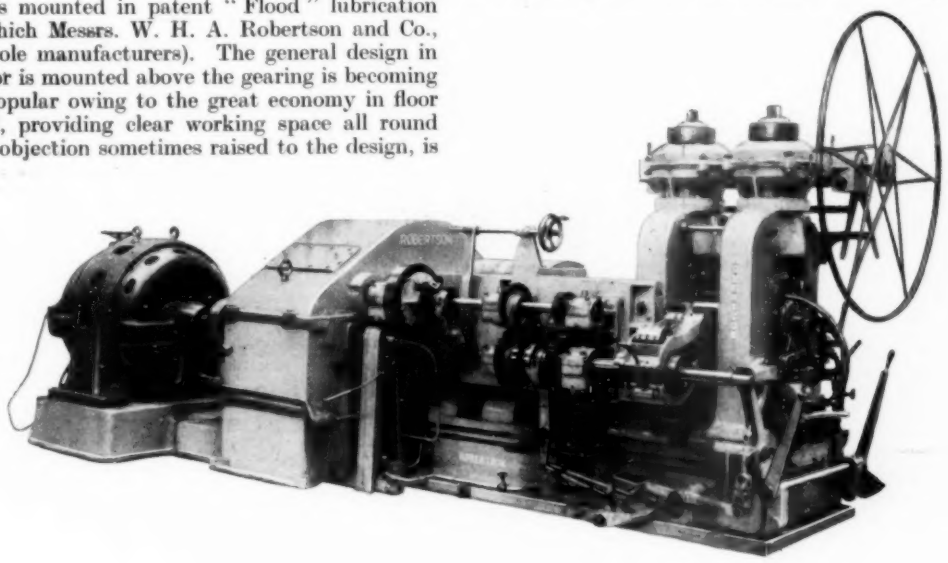


Fig. 6. Gearing arrangement on high speed mill of the type shown in Fig. 5.

that the dismantling of the gearcase in the event of breakdown is difficult, but with modern all-steel machine-cut gearing, with oil-spray lubrication, the gears are practically immune from risk of breakdown and will give an almost indefinite period of trouble-free service. High-speed mills with motor on floor level are also built, the more usual size of gearing arrangement being shown in Fig. 6, which is otherwise exactly similar to the mill Fig. 5, having 10-in. diameter rolls and a rolling speed of 300 ft. per min.

From the above it will be seen that a modern brass-strip mill may consist of entirely self-contained independent high-production units, with rolling speeds graduated to give a balanced rate of production. Such an installation may consist of:—

	Rolling Speed. ft. per min.
(1) One cold-breaking-down mill with rolls 20 in. to 24 in. diameter	75–100
(2) One intermediate or "getting-down mill" rolls, 16 in. at	200
(3) One or two "getting-ready" and finishing mills, 14 in. diameter	250
(4) One or two finishing mills, 12 in. diameter	300
(5) One or two finishing mills for narrower thin strip, 10 in. diameter	350–400

Items (1) to (4) would provide for a production of strip from 12 in to 16 in. wide, and the complete installation would be capable of a production in average gauges of 120 to 240 tons per week (single shift), according to the number of each size of finishing mills installed. The smaller mill, item (5), is specially efficient for finishing thin brass and copper strip up to 10 in. wide in gauge from 0·012 down to 0·003 in. thick.

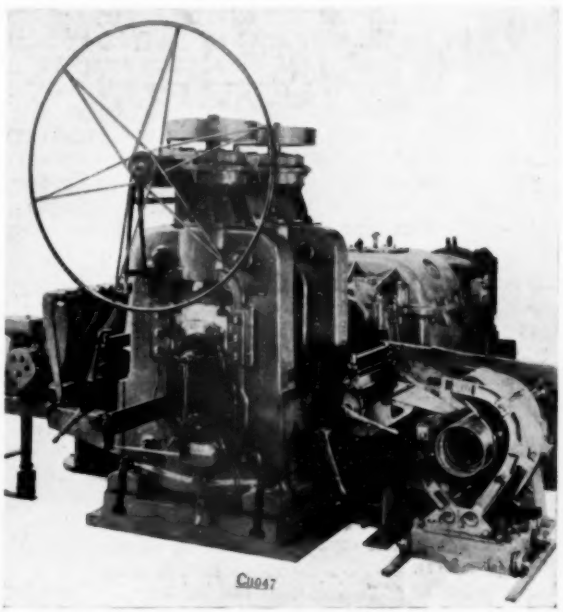
In wider strip and strip-sheet production, a large high-speed mill, with rolls 18 in. diameter, 32-in. face, rolling speed 200–400 ft. per min., and with electrically operated roll adjustment and automatic coiling and handling equipment, is representative of the most up-to-date wide-strip mill, which has proved highly efficient for finishing strip up to 26 in. wide.

For some requirements a reversing mill is preferred for intermediate and finishing passes, as mill shown by Fig. 8, which has rolls 16 in. diameter with automatic coilers on both sides of mill. This mill is operating at a moderate speed of 140 ft. per min. The question of the relative advantages of reversible and non-reversible working, is one on which no very definite opinion can be given, as so much depends on the class of work to be handled; generally, it may be stated that coils of considerable weight and corresponding greater widths are essential for maximum economy in a reversing mill. But even with normal weight of coil the reversing mill has some advantages; for instance, in a mill where floor space is limited and proper facilities for transporting coils, after a pass to the inlet side of rolls, are not possible. It would seem, however, that a non-reversible mill with convenient coil conveyers, by means of which the coils are automatically returned to the feed side of a unidirectional mill, would be equally efficient.

For very wide strip in copper and most brass alloys, breaking-down from heavy ingots to about ¼ in. thick is best effected in a hot mill, generally of the normal two-high reversible type with live roller tables and automatic coiling. In this case the intermediate cold-rolling is by means of a powerful four-high reversing mill, similar to those described later, and finishing is most satisfactorily accomplished in a two-high mill as previously described.

(To be continued.)

Fig. 7.—Reversing mill with coilers on both sides.



Cylinder Bore Finish and Wear

The latest methods, finishes and materials, considered to be the most suitable to reduce cylinder-bore wear, were discussed in a recent paper before the Institute of Automobile Engineers, the following article being an abridgment.

DURING recent years much time and money has been spent by motor-car manufacturers and machine-tool makers in developing various methods of finishing cylinder bores, also in machining operations prior to finishing, with the result that cylinder life generally, has been lengthened. The efforts of manufacturers of pistons, rings, cylinder liners and lubricating-oil producers have also contributed in no small degree to this desirable end. Obviously the subject of material and of surface finish cannot be divorced from pistons, rings, lubricants, etc., when length of service is considered. Thus, a recent paper by Mr. K. Brozyna, dealing with cylinder material and finish, with special reference to cylinder-bore finish from the users' point of view as distinct from that of the casting manufacturers', presented at a meeting of the Institution of Automobile Engineers, held in Manchester, proved a very comprehensive review of the subject.

The importance of cylinder-bore finish in relation to performance and cylinder life has been stressed lately. Only a comparatively short time ago cylinder material was considered to be the outstanding factor as regards life, and wear was thought to be in direct ratio to the hardness of the materials used. To-day, when most manufacturers use a good quality cast iron, the question of hardness arises chiefly in comparing similar castings of a batch of a particular foundry, and the question of the most suitable finish to apply to such materials is claimed by Mr. Brozyna to be the one which is occupying most attention amongst producers. In the paper he reviews very thoroughly the various methods employed in the finishing of cylinder bores, and discusses their respective merits. Twelve methods of finishing the bores are discussed.

It need only be pointed out here that fine boring is carried out with heavy and vibrationless machines in conjunction with a single free-cutting tool, consisting of hard material such as Widia or diamond, with the highest admissible cutting speed and with the smallest feed. The important feature of this method is that the radial pressures of the tool against the surface of the work, which used to be considered inevitable and which caused heating up and local damage to the surface, is now eliminated. As a further refinement a number of firms are now producing cylinder bores which are given a mirror finish by a honing operation after fine boring. This system seems to be the last word as regards obtaining, not only a high degree of accuracy, but also the desired finish, the finish thus obtained corresponding to that of an already well run-in engine combined with the advantage of extreme accuracy and represents one of the greatest advances made towards producing the ideal finish capable of being produced along mass-production lines.

Materials

Since motor cylinders, due to the modern design of combining mono-bloc and crankcase in one piece, have become more difficult to cast and irons with high phosphorus and high total carbon giving fluidity are liable to porosity and brittleness, the cast irons are more favoured now with a lower phosphorus and total carbon. To make this run easier a high silicon content is used. To counteract the softness with high silicon a small percentage of chromium is used, which stabilises the combined carbon. This gives an iron of uniform pearlitic structure, dense and free from hard spots, unaffected by mass effects and easily machineable. Both nickel and chromium are frequently alloyed with the iron.

Among other materials worth mentioning is the austenitic iron with approximately 14–16% nickel, 2–4% chromium, 6–7% copper, or an iron alloyed with about 20–25% Monel metal, which is chiefly used for cylinder liners, being particularly suitable in conjunction with aluminium cylinders. The use of liners permits a much larger range of wear-resisting materials in comparison with that possible by the more orthodox cylinder-block construction.

Cylinder Wear

It can be said that cylinder-bore wear could be prevented if "efficient lubrication" could be maintained. But the provision of completely satisfactory upper-cylinder lubrication is a problem not yet solved. The lubrication technologists cannot be very well blamed for this, as excellent progress has been made with some of the new "process oils" of certain famous oil manufacturers.

When it is realised (as has been found) that the flame temperature at the start of combustion is about 2,400° C., at the end of the power stroke 1,670° C., and about 900° C. at the end of the exhaust stroke, and that this latter temperature is greatly in excess of the carbonization temperature of the oil (about 400° C.), it appears that at the moment the problem ought to be studied from another viewpoint.

Cylinder wear can hardly ever be attributed to any single factor, but usually to a combination of several, as, for instance, to the effects of corrosion at low cylinder-wall temperature, as emphasised by the report issued by the Research Department of the Institution of Automobile Engineers, or to abrasion above a certain wall temperature, etc.

It will be appreciated that the most suitable material for cylinder-blocks and the finest finish of cylinder bores, will not suffice to prevent excessive bore wear if other controlling factors are not carefully considered. In this respect, effects must be made to improve gas blowing. This is one of the main causes of cylinder wear, on account of the destruction of the oil film, due to the gas-blowing preceding the downward passage of the rings (apart from gas-pressure loading of the rings), the ring-groove enlargement must be prevented as far as possible, and rings must make an efficient seal. To ensure this, the hardness of present-day light alloy pistons must be sufficient at elevated temperatures, and the side faces of the grooves and rings must be perfectly flat and smooth and piston-ring face must bed quickly to the cylinder wall.

A number of processes have been patented for producing a superficial hardness on aluminium alloys by electrolytic oxidation, such as the "Alumilite" process, which is proving very successful as applied to pistons. The piston-ring material must be heat-resisting, otherwise at high temperatures the tension will be seriously affected.

The demands made on the piston ring, namely, that it should seal in the shortest running time, and yet should not wear during running-in, are really contradictory, as the first condition can be got by a rough finish of the surface or by having a small initial contact surface, the second, however, by having the smoothest surface, and this to be as large as possible. With the highly accurate and finely-finished bores now possible the most practical compromise for production appears to be a ring with lapped side faces and a fine turned outside face, or with a small contact surface such as the one-degree "quick seating" taper rings or convex rings, etc.

Finally, Mr. Brozyna stated that to reduce cylinder-bore wear the principal points to be considered are :—

Suitable material for cylinders or liners.

Suitable finish and accuracy of bore at all temperatures.

Pistons and rings to be of a suitable design and material hard enough at elevated temperatures ; ring grooves and piston-ring side face to be accurate and smooth in conjunction with quick-seating face of ring to prevent gas-blowing.

Provisions made to quicken warming-up of cylinder walls to shorten time of running engine below a certain temperature and to minimise damage caused by cold starting by using means to lubricate top of cylinder.

To use suitable lubricant and fuel.

Under severe local conditions use efficient air cleaners.

The Cupola and Good Quality Castings

By WALTER WEST

The demand of the engineer is for a cast iron with a tensile strength ranging from 15 to 20 tons per square inch, accompanied by perfect soundness in the thicker sections. This is the proposition that most foundrymen and metallurgists have to meet from the ordinarg type of cupola. In this article the author discusses control of the ordinary elements in cast iron to meet this demand

THE advancement which has been made during the past decade in the quality of cast iron for general purposes, is clearly indicated in the revised specifications which have been published from time to time over this period.

Additions of alloys, nickel, copper, molybdenum, chromium, alone or in combination, bring important changes to strength (fatigue, transverse, compressive, shear, etc.), resistance to wear, and to corrosion, shock resistance, and outstanding duration at elevated temperatures. Such additions, when used with discretion and due regard to the composition to which they are alloyed, give benefits which far outweigh the cost and in many cases can only be obtained in this way.

The attainable properties, however, which can be had from an unalloyed metal are not generally appreciated and are frequently subordinated to get a low cost with a known or unknown sacrifice in the usefulness. This consideration, therefore, is confined to cast iron having the usual elements of total carbon, silicon, sulphur, manganese and phosphorus, and the blending of these into such compositions and the subsequent melting of them to give the highest strength compatible with the most desirable machining properties, and the minimum of difficulty in the production of castings in the foundry.

The modification of these ordinary elements in cast iron can be carried over such a wide and varied field to suit the manifold requirements of physical properties and machine-shop requirements, that the question of cost should not be allowed to dominate the production of them, because the extremity is well within the margin of a competitive product.

The method of melting can be such that any particular unit may be ruled out, or on the other hand an expensive unit as a capital outlay may amply justify itself over an extended period by the very fact that in melting what is known as ordinary cast iron, the ability to use cast-iron borings alone would warrant its operation.

The cupola furnace, however, still holds a very prominent place, chiefly because of the well-known characteristics of low initial cost, accessibility of operation, and of increased efficiency through the application of balanced blast, etc.

Failure to obtain the best results therefore, can invariably be traced to an incomplete understanding of the properties obtainable and in a measure due to a lack of proper test methods and control of operations. The advancement is more particularly in these directions and the situation is rapidly changing.

Carbon Control

In the consideration of these ordinary elements in cast iron and their respective behaviour one with another, foundrymen in general have not yet realised the great effect the amount of total carbon present has upon the physical properties and its behaviour during the cooling range. That this fact has been partially recognised can be confirmed by the amount of refined iron that is produced and offered for sale. The market is invariably found among those founders of intricate design castings, but the larger proportion of them still remain unconscious of the benefit to be derived from carbon control. If the fact is known, then justification is often sought in the reasons that such control is beset with foundry troubles, or that the price of refined iron puts its use out of question. This is no general recommendation for the use of refined irons, but alternatively a plea that there could be a more extensive control of total carbon and silicon by well-known means adaptable within the foundry.

American foundry practice effects this control through the duplex process of melting the pig iron in the cupola and adjusting the carbon content and the other elements in an electric furnace. Other means of achieving the same end are to be found in the use of rotary furnaces, oil or coal fired, or air furnaces, but under conditions which do not allow of the utilisation of the special furnaces, excellent results can and are being produced from the cupola alone.

This is just the principle of the manufacture of special irons such as "Emmel," "Mechanite," Ermalite" and inoculated irons. All these are modified methods of producing irons with very little difference in chemical composition and give structures which are for the most part entirely of a pearlitic character with a formation of finely distributed graphite, two factors which immediately produce much higher tensile and transverse strengths. An average of 29 tons tensile strength is claimed with material so produced.

For the greater part, the demand of the engineering trade in particular is for a cast iron with a tensile strength ranging from 15 to 20 tons per sq. in., accompanied by perfect soundness in the thicker sections. It is this proposition that most foundrymen and metallurgists have to meet, to produce the results from the ordinary type of cupola, or with some of the modifications at present available.

It should be known by all, that to meet these requirements, the high carbon content of the present-day pig irons needs to be reduced. Apart from the purchase of refined irons—*i.e.*, irons incorporating pig iron and scrap, and treated in some melting unit, there is no alternative to the use of steel scrap in the cupola charges. This practice of adding steel is, of course, an old one, and in some cases serves the purpose extremely well, but for castings in which the composition has to be maintained within narrow limits, to avoid hardness on the one hand or slight porosity on the other, direct additions of steel leaves open the possibility of selective melting and is highly dangerous.

The above-stated conditions are subject to one or two exceptions, for when working with large cupolas, say over 3 ft. 6 in. diameter, the danger of selective melting is considerably reduced by the opportunity of providing an amply large enough well or even a receiver or fore-hearth in which to effect a perfect mixing of the charge in bulk. For the production of lighter castings, this has a distinct disadvantage owing to the loss of temperature of the metal, especially where the smaller sizes of cupolas are in operation.

It remains, therefore, for carbon control to be exercised through the medium of double melting,—*i.e.*, in the making separately in the cupola pig iron with the carbon content required. This system is admirably suited to those founders who have to produce varying designs of castings, as the raw material can be altered to suit at will.

The degree to which the total carbon in any composition occurs has a very marked effect upon the mechanical properties of the resulting iron, but as the percentage is lowered below 3·0%, so a distinct tendency of the molten iron to external sinking becomes apparent. The work of the writer as published in METALLURGIA, October issue,

1931, shows that this external sinking is entirely connected with the amount of total carbon present. Series of experiments were carried through—(1) To find whether it was a direct effect of the low total carbon content (2) Could it be eliminated by a reduction or an increase in the silicon content (3) Would superheating the molten iron counteract the effect.

Silicon as Balance

The attaining of high-strength irons with an all-pearlitic structure is very greatly to be desired where the casting is called upon to withstand stresses of any kind, and because of this, room has been made for the patented processes before mentioned, which direct operations to a carbon content between 2·0 and 3·0%, and to balance with a corresponding high silicon, and so produce the desired structure and solidity in section.

In every case where this principle operates, it is necessary to provide what normal iron foundry practice terms large feeding reservoirs, to overcome the well-marked suckling or sinking which occurs.

Even with moderately reduced carbons, the results of the experiments referred to proved that neither higher silicon content nor yet superheating could overcome the degree to which the sinking effect occurred, and that to completely avoid it a total carbon content of not less than 3·0% had to be employed.

The strength of the iron as expressed in the recognised terms, with such a limitation of carbon, can be increased or decreased by a variation of the silicon content, accepting that other elements remain constant.

The use of steel in any mixture within defined limits aids the increase of strength in a direction further than a control of the total carbon content. Automatically a reduction of phosphorus occurs in the mixture, and not a few workers have proved that the presence of this element increases the tensile strength up to 0·3%, after which it causes a continued decrease in strength. In addition it is now well confirmed in practice that solidity of heavy sections is largely assisted by a limitation of this element to 0·3% as a maximum.

Low Phosphorus Irons

The outstanding demand which low phosphorus medium carbon cast iron makes upon cupola practice, is that the melting should be as hot as ever possible; this condition, if obtained, serves to good purpose, as the graphite separaiton is of a finer formation and very satisfactory results are obtained during the subsequent machining processes.

One undesirable result has been experienced by the use of cast iron of this composition. Where castings are of intricate internal design and the metal has to run through many narrow interstices of the mould, there is every likelihood of trapped gas pockets being revealed where such castings are machined on the face, which has been uppermost during the casting operation. These may be eliminated in some cases by an alteration to the method of running the casting, but in others where this top face is flat and not continuous, being intercepted by many cored portions, no matter what system of running is adopted, or the way the cores are vented, the metal appears to carry with it a certain amount of entrapped air or gas, possibly formed through a turbulation of the metal set up during its passage through the mould.

Because of the short freezing range of this particular type of iron, such pockets of entrapped air or gas, are carried to the top of the mould and in some cases are not liberated before the actual setting of the metal. Evidence of the correctness of this interpretation is to be found in the fact that on exposing such voids or pockets, in most cases a small bead of metal is enclosed.

Aluminium to Improve Fluidity.

Singularly enough this phenomenon is not affected by an increase in temperature up to 1,400° C., but rather inclines to be increased. An immediate elimination of the trouble can be had by the use of a higher phosphorus content, but this is undesirable for certain types of castings. This fact, however, would indicate that some connection occurs between the trouble and the lack of fluidity which is characteristic of low phosphorus iron. To improve this property, it has been found that aluminium additions to the metal in the ladle has a very marked effect.

The use of this metal has perhaps been more confined to the older school of foundrymen who realised that a small amount was a very valuable method of recovering fluidity to dull iron. In this suggested case, where temperature is not lacking in any degree, it may be that through an increased surface tension on the liquid iron set up by the solution of the aluminium in the metal a condition is produced which is less sensitive to turbulation.

Whatever the theory may be, the practical results are well defined and worthy of notice. So small a quantity as two to four ounces to the ton of metal is sufficient to bring the desired results, and in addition it will be found that the metal behaves with a minimum of biting effect upon the sand of the mould, and so produces an extraordinary smooth and clean surface on the casting. R. P. Lemoine in his exchange paper of the French Foundry Technical Association, before the Fifth International Foundry Congress and 1934 Convention of the A.F.A., gives definite confirmation of the writer's experience. Recording his findings with a 2% silicon iron especially if connected with a 2·60 or 2·65% carbon, melted in the cupola by the usual method of steel charges, he relates that one of the chief troubles experienced is "lack of castability," resulting in short runs or round edges of thin sections, and blow holes in others, air and gas bubbles had not time to escape before the iron solidified and they remain entrapped.

In this case he attributes the "lack of castability" to a combination of low carbon and too low silicon content. It would be pertinent to suggest that as the melt had been made by the usual method of steel additions and the phosphorus content is as low as 0·15%, that this makes a large contribution also. Further information in the paper gives a very practical hint that the addition of ferro-silicon or silico-calcium to the stream of metal tends to increase the fluidity of the iron. By so doing, it is highly probable that a similar result is obtained as when granulated aluminium is employed.

Creep-Resisting Steel

The use of high-steam pressures and temperatures is now established, and with it has come a demand for steel to withstand stress at temperatures of 350–500° C. At present, such high temperatures are confined to land power stations, but there is a tendency for pressure and temperatures to be advanced in marine and railway practice. Some five years ago the United Steel Companies, Ltd., introduced the "Durehete" creep-resisting steel, and this has now been extensively tested in service in this country with satisfactory results, and a book* describing the research work carried out in its development is available.

One of the most fruitful sources of loss of efficiency in the running of steam plants is leaky steam joints. In plant running at the normal temperatures and pressure, with care and ordinary materials this is not a serious problem, but in high-pressure plants ordinary materials are not good enough. In modern high-pressure superheated steam practice, the stresses and temperatures cause a very dangerous stretching of ordinary steels. Stud bolts made of ordinary steel will, therefore, be unsuitable for withstanding these conditions, as they will be subject to this continuous stretch, or, as it is technically known "creep."

This new steel is more resistant to "creep" than plain carbon steels, and at 500° C. the stress which may be safely applied to it is more than twice that which may be applied to mild steel without the "creep" being dangerous. It can therefore be designated as a "creep-resisting" steel.

*Obtainable from United Steel Companies, Ltd., 17, Westbourne Road, Sheffield, 10.

Town Gas in the Ferrous and Non-Ferrous Metals Industries—PART II

Specially Contributed

The accounts of various metal-heating processes carried out in gas-fired furnaces, described in the last issue, indicate the very wide field of individual applications already covered with gas as a supplier of heat. In this article more recent applications of gas as a heating medium and processing agent is described, particularly those involving atmosphere-control in the heat-treatment of high-speed steel.

A GREAT deal of work has been done in this country and abroad on what is termed "atmosphere control," and the Sheffield Gas Company has given much attention to this both for steel and non-ferrous metals. An account of processes, developed and industrially applied by the Sheffield Gas Company, in recent years is given here, but it is pointed out that gas is very successfully used as an atmosphere-controlling agent in many other ways, principally by virtue of the accurate control possible with its methods of combustion.

Atmosphere-Control Process for Hardening High-Speed Steels

The purpose of this process is to eliminate the formation of scale and to prevent decarburisation at one and the same time. On simple steels requiring low temperatures, the use of raw gas alone is capable of giving satisfactory results, but on complex steels requiring very high temperatures of the order of 1,300° C. heating requirements are far more difficult and exacting. Not only is the tendency to scale very much more pronounced than at low temperatures, but decarburisation takes place correspondingly easier. These two features result in loss of metal as scale and more loss to remove damaged surface by subsequent grinding. Also many tools such as complex dies and intricate edge tools are such that no loss of metal at the surface is tolerable. Badly damaged surfaces on steels are usually associated with incorrect internal structure, such as overheating, burning and excessive grain growth. These effects on the internal structure are indicated in faulty physical properties of a tool, notably in the hardness and ability to retain a cutting edge. These difficulties are at present overcome by the skill of furnace operators using time old customs, which have proved of some assistance but these methods are costly, especially in material and labour.

The foregoing difficulties are precisely what this new process of atmosphere-control is designed to eliminate. Its value may be summarised as follows:

1. The process is so simple that no particular skill on the part of an operator is required.
2. The cost of the process in use is not more than 2% of the gas cost to heat the furnace, when the working temperature is 1,350° C.
3. There is not more than 1/10,000th of an inch of scale at 1,350° C.
4. There is no decarburisation.
5. There is no burning or pitting.
6. There is much less tendency to grain growth.
7. The best internal structures can easily be obtained.
8. The process is applicable to any steel at any heat-treatment temperature.

The direct practical and economic advantages of such a process can be immediately appreciated, and the number of manufacturers who have tested and approved the claims of the process leaves no doubt of its industrial value.

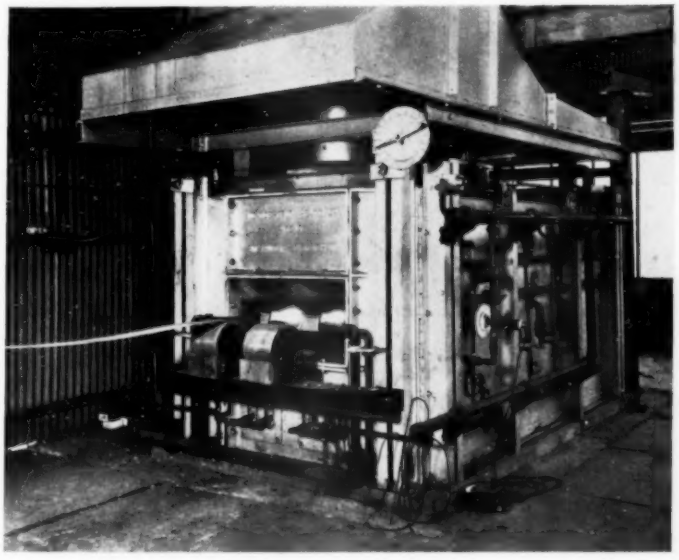


Fig. 6.—Continuous strip annealing furnace, for the treatment of stainless steels of different compositions. The furnace is used in "line production" of finished strip, the strip being annealed, cooled, pickled, scrubbed and dried continuously.

One feature which has been recognised since the process has been in practical use adds considerable value to its adoption. Tools treated under correct atmosphere-controlled conditions have a longer cutting life than similar tools treated under ordinary conditions. Cutting tests on high-speed steel reamers, twist drills and hobs have shown a 100%–400% increase in life over similar tools treated by standard practices. These tests have been carried out by steel firms who are adopting the process.

The following description of the method of working and the chemistry of the process of atmosphere-control will be of interest, and will indicate how its special features are obtainable in practice.

Explanation of Atmosphere-Control Principle

The principle used has two major functions.

1. It creates a positive pressure inside the working chamber, thus preventing ingress of air from the outside.
2. It provides the exact atmosphere required for any steel at any desired temperature.

The apparatus used to provide atmosphere-control is so designed and arranged that it causes a flow of the waste products of combustion from the heating chamber to the working chamber—a muffle. This flow of waste products is due partly to the slight pressure in the heating chamber, and to the thermal circulation produced by alternate heating and cooling through the system. Once the furnace has been lighted, this flow takes place automatically and its degree can be controlled by very simple operations to be described later.

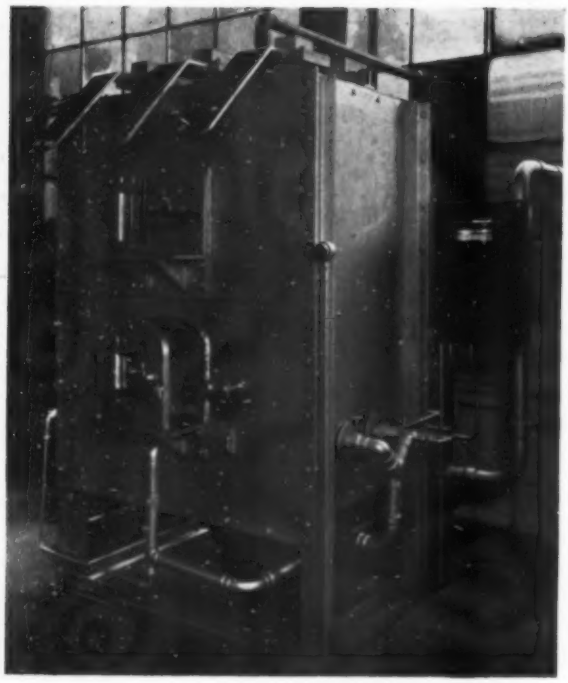


Fig. 7.—Atmosphere-controlled furnace, of the type developed by the Sheffield Gas Company, for the hardening of high-speed steel tools without scale or decarburisation. The furnace is both atmosphere-controlled and temperture-controlled. The functioning of this atmosphere-control system is fully described in the text of this article.

The principal part of the apparatus is a cooler, so designed that the waste products of combustion from the heating chamber are cooled to shop-temperature by means of the pressure air used to burn the gas to heat the furnace. The cooler then has a two-fold function.

1. It cools the waste products of combustion, and hence lowers their water-vapour content.
2. It pre-heats the air used for combustion.

The cooled products issuing from the cooler are of such a chemical composition that their scaling and decarburising properties are considerably less than before the waste products entered the cooler. This is due to one primary cause, the very low water-vapour content, and as water-vapour has been shown conclusively to be a very important factor in scale formation and decarburisation at temperatures such as 1,300° C., this low percentage is an advance in the right direction. The other gases in the mixture leaving the cooler are carbon dioxide and nitrogen. Nitrogen is without effect on steel, but the carbon dioxide, in the presence of the small amount of water-vapour is capable both of scale formation and of decarburisation, but to a less marked degree than either water-vapour or air. To overcome even this slight tendency to effect the surface and carbon content of a steel, a small amount of unburned town's gas is added to the mixture leaving the cooler in such a way that efficient mixing takes place.

When this mixture of gases passes into the working chamber it rises in temperature and chemical-inter-reactions take place, resulting in the production of a mixture of gases of entirely new composition. The composition of this mixture depends upon the temperature of the furnace, when using any one particular ratio of cooled products of combustion and unburned gas. This ratio is under definite and simple control. By means of graduated stop-cocks to the supplies of products of combustion and unburned gas, any desired mixture can be obtained. This, along with changes known to be produced by the temperature of the furnace, allows any type of atmosphere as may be desired to be produced in the furnace. These atmospheres are not to be confused with those usually referred to as oxidising, reducing or neutral. They are actually " balanced atmospheres " adjusted by a consideration of the composition of the steel being heated and the temperature of operation.

In actual practice the operator requires merely to alter the ratio of products of combustion to unburned gas added, by means of the two stop-cocks provided, until the steel being heated shows no scale and no decarburisation. Once the setting of the stop-cocks has been determined, that same setting can be used on all future occasions for the same type of steel.

The results obtained with any class of steel requiring to be heated at any temperature up to 1,385° C. are perfectly consistent and it can be guaranteed that there is no decarburisation and not more than 1/10,000th of an inch of scale.

The advantages of heating steel without the formation of scale and without decarburisation by this process are of tremendous importance and the major points may be summarised as follows :—

1. No allowance for grinding need be made. The article heated requires only a slight sand blast and polish to render it a saleable product. This not only means a saving in the amount of steel, but reduces to a minimum labour charges for grinding, and costs of grinding wheels.
2. The percentage of wasted material due to badly damaged surface is reduced to practically nothing.
3. The cost of protecting material and devices used in many other processes is eliminated.

An Important feature of Atmosphere-Control by this System

The quality of a steel article depends primarily upon its internal structure and not merely upon the type of surface it shows. This quality is a variable function of the type of steel, the temperature to which it has been raised, the time of heating, and the method of quenching, etc.

For any one type of steel and method of quenching the remaining variables are time and temperature. The very close attention to the period of heating in the trade is well known. Even seconds are considered. The temperature, too, is usually recorded or indicated on an instrument of proved merit. The need for these very careful methods is to render the physical structure of the steel optimum for the particular purpose the article has to perform. This physical structure is often judged primarily by the type of fracture shown by the steel, and more accurately by the aid of a microscope on a correctly prepared surface. The degree of solution of carbides and the size of the individual crystals—the grain growth—are usually looked for. The amount of grain growth and degree of solution of carbides are favoured both by high temperature and time of heating, but as the degree of solution of carbides is required to be as high as possible and the amount of grain growth as small as possible, usually only a suitable average of the two can be attempted. That is, an upper temperature limit, which gives maximum solution of carbides with minimum grain-growth, has to be used in practice. The period of heating, too, has to be carefully adjusted to the particular temperature decided upon. In addition the choice of temperature and time is influenced by the degree of damage which may be done to the surface during the heating, but, in everyday practice, using ordinary methods of heating, freedom from surface damage has to be sacrificed.

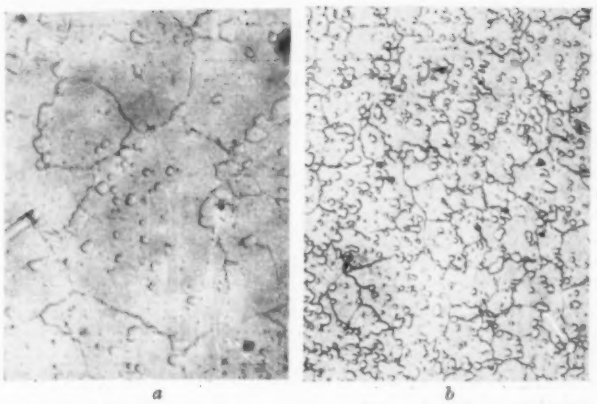
But with atmosphere control of the type developed by the Sheffield Gas Company, control is not only possible with regard to the surface of the steel, but also with the internal structure—the grain growth. That is, a steel article can be heated under controlled atmosphere conditions :—

1. At the usual temperature for longer periods.
2. For the usual period at higher temperatures.
3. Even for longer periods and higher temperatures without excessive grain-growth taking place, and without any scale formation or change of carbon content at the surface.

This control of grain growth is brought about by two factors :—

1. The gases present in the muffle working chamber are not hotter than the walls of the working chamber, whereas in an open-type furnace the gases in the working chamber are naturally hotter than the walls. This means that an article heated by radiant heat in a muffle cannot become hotter than the temperature recorded on the walls of the muffle, whereas an article in an open-type furnace can be hotter than the indicated temperature of the furnace.
2. When oxidising gases are present in a working chamber, the heat of reaction of these gases with the iron in the steel is sufficient to cause excessive overheating of the article, with the result that the article may be considerably higher in temperature than is indicated on the walls. This chemical reaction heating effect, combined with the effect in an open-type furnace, described in 1, results in the steel being heated at a higher temperature than is suggested by an instrument-indicated temperature of the furnace.

Therefore, in an atmosphere-controlled furnace of this type, the steel being heated is not over-heated by gas contact, and is not self-heated by chemical reaction of gases at the surface, and so exact temperature control of the articles being heated is automatically obtained, without the aid of a skilled furnace operator.



a *b*

Fig. 8.—Two photo-micrographs, × 600, of high-speed steel (18.4.1) heat-treated at 1,300° C. The time period of heating was three times longer than is normally used for the section of steel employed, to show the control of grain size which is possible with atmosphere-control of the kind described in this article.
(a) Showing steel treated without atmosphere-control.
(b) Shows the same kind and section of steel treated with atmosphere-control.

The control of the maximum temperature to which steel is raised, combined with a scale-free surface and a non-decarburised surface, results in an almost perfect heat-treatment.

(To be continued.)

The Relation of Laboratory Research to Engine Design

FOLLOWING a general discussion of the relation of laboratory research to engine design, Dipl. Ing. Hubert Hauttmann gave a comparison of the results of static and alternating tests in a paper read at a recent general meeting of the North-East Coast Institution of Engineers and Shipbuilders. Increasing acuteness of the notch angle, he stated, increases the static strength but decreases the fatigue strength. Errors have been made by disregarding this fact and by applying the results of tests made under conditions differing from those actually to be experienced by the material. Definitions of the terms "section factor," stress concentration factor" and "notch sensitivity" were given. The designer is recommended to utilise the results of laboratory fatigue tests and especially of actual experience regarding the failure of structural members, in order to obtain useful data for calculating the actual stresses, for critically examining the form of structural members and for judging the suitability of material.

The influence of the fibre on the fatigue strength of forged and forged and displaced crankshafts, respectively, was described as an example for the application of the results of laboratory tests to heavy-engine design. The charge of production method of cranks of the Gutehoffnungshutte caused by the results of tests, was discussed. Another example was used to discuss the effect of shrink fits on the endurance limit as determined by laboratory tests and its elimination by a change of design.

The application of the results of laboratory research concerning the influence of corrosion on the fatigue properties with regard to the working conditions of piston rods of double-acting oil engines was shown. The addition of a small amount of emulsifying oil to the cooling water was found practically to eliminate the corrosion effect in laboratory tests, as well as in practice.

Finally a special steel for alternately stressed welded members, developed by laboratory research, which reduces internal stresses at the seam through its high plasticity due to its very low elastic limit after a certain kind of heat treatment, was discussed. In recent years, the author stated the welded structures have been introduced into marine engineering and shipbuilding, owing to the possibility of saving weight. The metallurgist as well as the designer were confronted with entirely new problems as no practical experience regarding the materials to be used and their structural shaping were available at the time when alternately stressed welded structures were introduced. The development of suitable steel and the establishment of fundamental data for designing necessitated considerable laboratory research.

In searching for a suitable material mentioned requirements, Gutehoffnungshutte Oberhausen A.G. succeeded in developing a steel alloyed with manganese, copper and a small proportion of molybdenum, of which the proportional and elastic limit and also to a certain extent the yield point, can be changed within a wide range by annealing at different temperatures. This effect is obtained by the addition of a little molybdenum—about 0·1%—in conjunction with a higher manganese content. This steel is manufactured with a tensile strength of from 60–85,000 lb per sq. in. and contains not more than 0·2% of carbon. The extraordinary behaviour of the proportional and elastic limit after certain kinds of annealing renders the Mn-Cu-Mo alloyed steel especially suitable for welded constructions, because, in the zone of influence of the welding seam, where temperatures of over 1,300° F. prevail, and where at the same time conditions exist for the development of the highest stresses, this kind of steel, due to its lowered proportional and elastic limit, resulting from the thermal influences of the welding process, has the property of compensating the stresses by plastic deformations.

In this connection, the question arose whether the reduction of the elastic limit is not accompanied by a reduction of the endurance limit values. Tests in this respect have proved, however, that in the fatigue-tension test the endurance limit remains practically independent of the position of the elastic limit. In these fatigue-tension tests the low values of the proportional and elastic limits were evidenced by corresponding lengthening of the specimens, the endurance tension limit of 46,000 lb. per sq. in. being considerably higher than the elastic limit.

Reviews of Current Literature

Electroplating

A Survey of Modern Practice

THE science and art of electro-deposition has advanced considerably during recent years, and a further and enlarged edition of this book has become necessary to meet the needs of the industry. Systematic research upon some of the numerous and intricate problems associated with the subject has been rigorously pursued. Much light has been thrown upon several aspects of electroplating, and important conclusions have been reached upon phases of the subject having a direct bearing upon its extending practice. The author has endeavoured to incorporate the results of recent investigations in such a manner as to be understood and appreciated in the workshop. Obviously new scientific knowledge to be of any real value must permeate the workshop, and must continue to do so with the increasing applications of electrolysis to the adaptation of metals.

The majority of electroplaters will be in agreement with the authors in stressing the fundamental principles of electro-deposition, only through such channels can any hope exist for the extension of the processes and the production of deposits calculated to embrace the special properties now specified. The book deals with the deposition of copper, silver, gold, nickel, zinc, cadmium, chromium, and a variety of additional metals, also the deposition of alloys. Besides the fundamental principles of the subject, which are discussed in the opening chapters, sources of current, electroplating plant, properties of solutions, and mechanical and chemical cleaning of the parts to be treated, are discussed.

Closely allied to the general processes of electro-deposition are a number of operations of interest and importance, and in a chapter on allied processes, the authors consider many aspects of aluminium and a final chapter deals with metal colouring.

An appendix refers to electroplating chemicals and other useful information necessary to the successful application of the processes involved. The book is well prepared and will be invaluable to the electroplater, not only in keeping up to date with practice, but in becoming familiar with modern trends.

By Samuel Field, A.R.C.Sc., and A. Dudley Weill; published by Sir Isaac Pitman and Sons, Ltd., Parker-street, Kingsway, London, W.C. 2. Price, 7s. 6d. net.

A Biography of the Cutting of Metals

DURING recent years there has been remarkable progress in the use of ferrous and non-ferrous alloys. Primarily these have been developed to meet the more exacting and strenuous conditions of the engineer, but their development has raised many problems concerning their machinability, and much research on the cutting of metals has been carried in order to obtain knowledge on the subject. It has been found that comparatively small percentages of alloying elements frequently have a remarkable effect on the mechanical properties of metals; in addition these metals are often subjected to various treatments, so that they may possess certain characteristics not present in the untreated condition. It is not surprising, therefore, that under present conditions, success in the machine shop is dependent on much experimental work. Each newly developed metal or alloy must be studied in the light of experience. This, of course is an expensive method, unless it is possible to obtain all available information on the subject, and so benefit from a wider field of experimental work. The object of this bibliography is to give suitable references to facilitate the study of the cutting of metals. It is the second to be compiled by Professor O. W. Boston of the University of Michigan; the first consisted of some seven-hundred references with short abstracts. Since the publication of that bibliography, additional references dealing with metal-cutting tools, materials cut, and cutting fluids have been accumulated. These are now compiled in this new volume consisting of an additional 1,257 references with abstracts. The dates of some references overlap those of Part I., although the majority are for the years 1929–34, inclusive.

The references have been arranged chronologically by authors. They are indexed by authors and subject in a manner similar to that of the first bibliography. They are thus presented in a convenient form. This bibliography should be in the hands of all who are concerned with machinability problems. The previous edition was published by the American Society of Mechanical Engineers, but in order to make the present issue available to investigators, it has been published by the author, Professor O. W. Boston, University of Michigan, Ann Arbor, Michigan, U.S.A. Price, $2·50 net.

Hutchinson's Technical and Scientific Encyclopaedia

The work embraced by this encyclopædia traverses the whole field of physics, astrophysics, meteorology, horology, electrical communication; the whole field of chemistry, geology and mineralogy; crystal structure and radio-activity; the new sciences oceanography and geophysics. It embraces civil, mechanical and electrical engineering; mining; navigation; the science of aeronautics; the making of cinema films; the carbonisation of coal; the manufacture and dyeing of textiles, including artificial silk; the sources and manufacture of furs; the manufacture, properties and uses of metals; gems, watch and clock-making and jewellery; ship construction; fuels; and welding processes; all of which are fully considered.

In addition to the more lengthy articles, the terms used in pure and applied science, the principal manufacturing industries, and the skilled trades are defined, and commodities of botanical and zoological origin are named and described.

This encyclopædia has been specially planned to enable students, teachers, the learned professions, manufacturers, and skilled craftsmen to obtain information and data they require quickly. Apart from the information given, a valuable bibliography is included which gives a list of books and other sources of information on subjects of importance in pure and applied science, manufactures and skilled trades, which facilitate further study of particular sections upon which the reader seeks additional information.

The work is very comprehensive, and comprises over 2,400 pages, the text including thousands of diagrams and illustrations. It is bound in four volumes, royal octavo size, and, in addition to those for whom it has been specially planned, it will be particularly useful to the ever-growing public who desire to keep in touch with modern progress and who desire a ready means of reference to enable them to understand how science is applied to industry.

Edited by C. F. Tweney and I. P. Shirshov, and published by Hutchinson and Co. (Publishers), Ltd., Paternoster House, London, E.C. 4. Price, 20s. per volume.

Striations in Tin Coatings on Copper

Under certain conditions of tinning, striations are plainly visible to the naked eye across strips of copper which have been allowed to cool from one end so that crystallisation occurs uniformly in one direction. In ordinary practice the irregular cooling of the coating prevents the striations occurring in a regular and obvious pattern, but they then form concentrically about the nuclei of crystallisation. Under a low-power microscope the pattern is seen to consist of alternate smooth and mottled surfaces across the single crystals of tin. In this paper it is shown that the effect is due to the crystal facets being inclined to the surface in a periodically varying manner within the single crystals of tin.

Copies of the above paper by Dr. Bruce Chalmers and Dr. W. D. Jones may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C. 2.

Research on Yield Limits and the Tensile Strength of Mild Steel and other Metals

By Prof. Dr. G. WELTER, Warsaw

On the basis of critical considerations, the tension-elongation diagram of soft steel and other plastic materials is not in conformity with facts. It is not conceivable that the load should drop away at the upper yield limit; similarly, a falling away of the load from the maximum load limit down to breakage of test-pieces with considerable contraction is not possible. By means of laboratory tests, the viewpoints deduced have been confirmed by showing on the basis of direct weight-loading of the test bars that there is no upper yield limit with mild steel, and that with plastic materials there is no kind of drop of maximum load limit to be recorded prior to breakage. The diagrams recorded by the usual tensile-test machines do not agree with the real properties of the material, and call for major correction. The need arises for adapting tensile-test machines to these conditions, and to reconstruct them on the lines of machines operated by direct weight loading.

THE yield-point and the tensile strength of various materials is a matter of great importance. Our knowledge of these properties, however, has not as yet been clarified to such extent as to allow an incontrovertible opinion being formed as to the deformation phenomena within the materials, both at the yield limit and in the further course of the load-elongation diagrams. The study embraced by this work is designed as a contribution towards the purely mechanical stress-elongation behaviour of the yield process.

The Problem and Considerations for Solving It

If we contemplate the tension-elongation diagram of mild steel, two characteristic points will claim our special interest. After having been accustomed for many years to these diagrams, which have been evolved as a standard figure since the early beginning of material testing, we are no longer struck by the contradictory features presented by these points, and they no longer excite our criticism. As will be gathered from such a standard diagram for soft ingot steel, as is shown in Fig. 1, it is the phenomena at the yield limit, point A, and of the maximum load limit

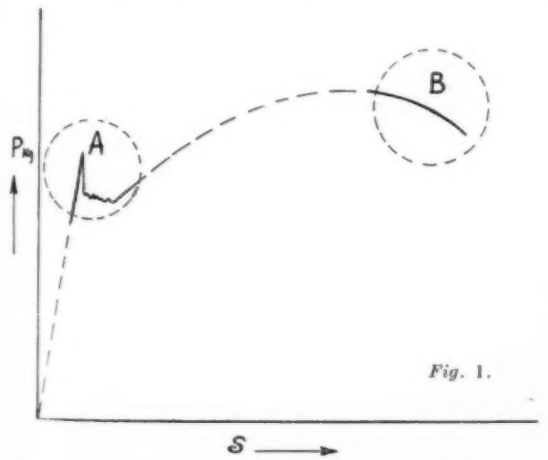


Fig. 1.

and breaking strain in the descending branch of the diagram point B, upon which attention is directed. This almost classical diagram is perfectly commonplace to us, and may be regarded as a symbol, as it were, for the science of testing materials, although it presents evident contradictions. On contemplating this diagram more closely, it will be remarked that the two points A and B, where such fundamental changes occur within the material, show a behaviour which will not stand up to plain though slightly more thorough criticism.

It is well known that mild steel will give a tension-elongation diagram, showing that frequently a very distinct upper and lower yield limit will be recorded by the tensile machine in the diagram. When loading such a test-bar, the tension P will rise up to an upper limit A (Fig. 2), whereupon a sudden and quite distinct drop in tension will occur up to the point B; it is only then that the yield process proper will begin at approximately constant load. This diminution of load in the machine (A—B) may amount to 30–40% of the maximum load at A, according to the circumstances and may occasionally be even higher than the breaking strain of the material.[1]

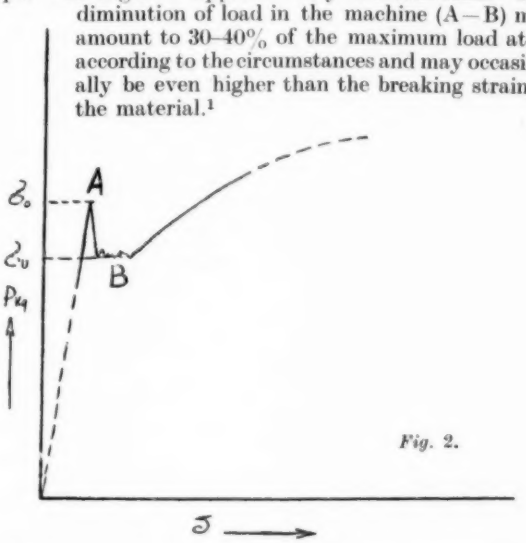


Fig. 2.

This instantaneous drop in tension A—B, as recorded by the dynamometer of the tensile-test machine, and which indicates the catastrophal character of a collapse of the material, is correlated in technical literature with a metastability of the conditions of strain within the material (similar to undercooling of a molten fluid below its melting point), and is theoretically evaluated in various manners.[2]

Furthermore, the course of the diagram from the maximum load limit at C (Fig. 3) to that at which the rod is elongated uniformly over its entire length, shows an exceedingly characteristic drop in tension from C to D—that is, from the moment when the local elongation develops as expressed by the contraction of the test-bar. According to our present conceptions, therefore, a breakage of the test-bar will occur at D under a load which is materially less than the maximum load at C. The drop in tension may amount to approximately 30–50% and more of the

1 C. Bach and R. Baumann. "Resistance Properties and Structure Diagrams of Structural Materials." Second Edition. 1921. P. 6.

2 F. Körber. "The Problem of the Yield-point." International Congress for Testing of Industrial Materials, Amsterdam, 1927. F. Körber. "Communications of the Kaiser-Wilhelm Institute für Iron Research, Düsseldorf." Treatise 263, vol. xvi., issue of September 3rd, 1934. A. Nadai. "Journal of Technical Physics," 5/1924, p. 369.

maximum load, as will be gathered from a survey of a number of rupture diagrams.

A somewhat more critical examination of the yield process at A—B and C—D (Figs. 2 and 3), supported by

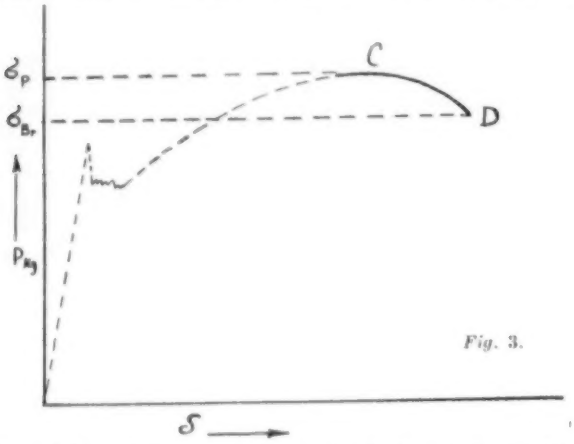


Fig. 3.

the setting of the question as to whether it is possible for the load once applied to the test-bar to drop at all, will cause serious doubts to arise as to whether such tension-elongation diagrams by tensile machines are actually true to reality. By setting the question what such a diagram would look like when using a tensile machine causing the strain in the test-piece by direct-weight loading in contradistinction to the usual designs, the solution of the problem was also practically provided. Slight reflection will show that it is not very conceivable that this standard diagram would retain its characteristic drop-points at A—B and C—D under a direct weight-loading of the test-bar. It is hardly imaginable that the load once applied should drop, due to an internal yield process within the material in such a conspicuous manner.

The load absorbed and carried by the test-bar cannot possibly become less when the rod expands, even when this occurs to a considerable extent. At best, a constant load may cause an increasing elongation of the material—a process with which we are amply acquainted from creep tests. But, as during the usual standard tensile tests, the test-bar is broken by a steadily increasing load, an increase in elongation without increase in load is not conceivable. It is possible that the rod may expand rapidly beyond comparison under an increase in load which may be exceedingly small, yet existant. According to these considerations, therefore, the tensile diagram

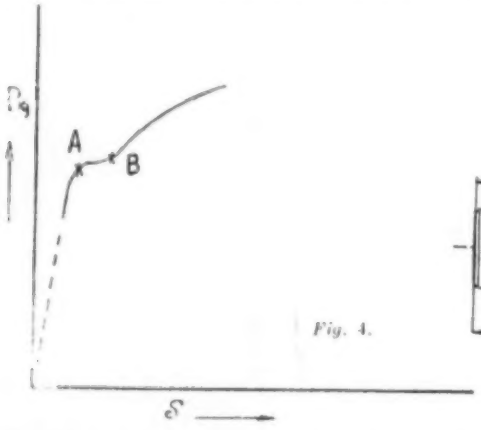


Fig. 4.

of mild steel cannot present any abrupt, discontinuous zig-zag line indicative of a diminishing load. It can only consist of a curve with a constant tendency upwards as in Fig. 4, indicating the beginning of the yield limit where the direction of the curve is broken at A and the end of this range at the point B. Owing to the period of constantly progressing increase in load between A and B, the point B must invariably be higher than A, even if occasionally by an insignificant amount only.

Similarly, it is not conceivable that a drop in load should

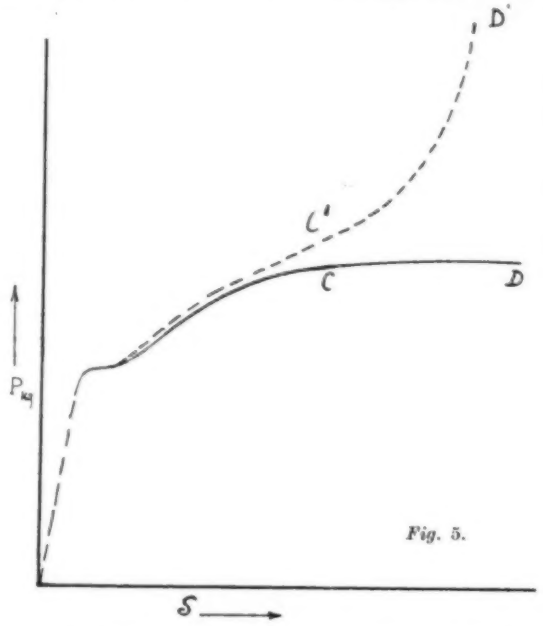


Fig. 5.

occur at the beginning of local contraction towards the end of the tension diagram at the point C, as shown in Fig. 3. Although the bar will contract locally with exceedingly heavy elongation, nevertheless the load does not drop, but up to the point D (Fig. 5) it will show an increase, possibly a negligible amount, according to the yielding capacity of the material. Consequently, the curve of *effective* loading C'—D'—that is, of those loads relating to the particular minimum test section—will have to show another course than that calculated from the standard diagrams showing considerable tension drop between C and D. This further shows that our understanding of the absolute, effective loading of materials, according to a reproduction of the tension-elongation diagram based upon an unsuitable design of the tensile machines is wrong, and have been calculated too low.

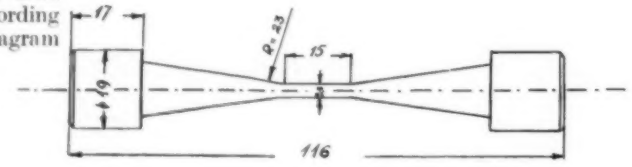
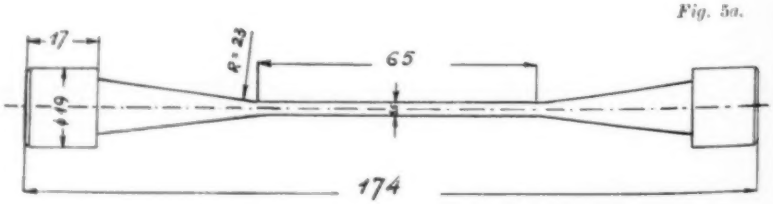


Fig. 5a.



Description of Test Equipment

The laboratory investigations carried out to prove the arguments set forth are only considered briefly, because very simple test conditions are involved. The testing machine employed is a vertical 5-ton Amsler tensile machine (type 5 ZD 181) with weight pendulum, load indicator, and curve recorder, having spindle drive for manual or motor operation. Having regard to the direct weight loading, the test-bars used were of a diameter of 3·5 mm. with

tapered transition portions leading to the cylindrical rod heads. Rods of different measured lengths, of 15 mm. and 65 mm. were used (Fig. 5a). Soft carbon steel of approximately 0·15% C was used as material, which had been annealed at approximately 800° C. The upper yield limit for these tests was round about 370 kilos. of load, the lower yield limit 320 kilos., while the breaking load was approximately 470 kilos. In order to record the tensile diagrams, the dynamometer of the machine was set to a maximum load of 500 kilos., and the diagrams were therefore recorded by the machine on an adequately large scale. For direct weight loading the lower, movable clamping head was disconnected from the vertical driving

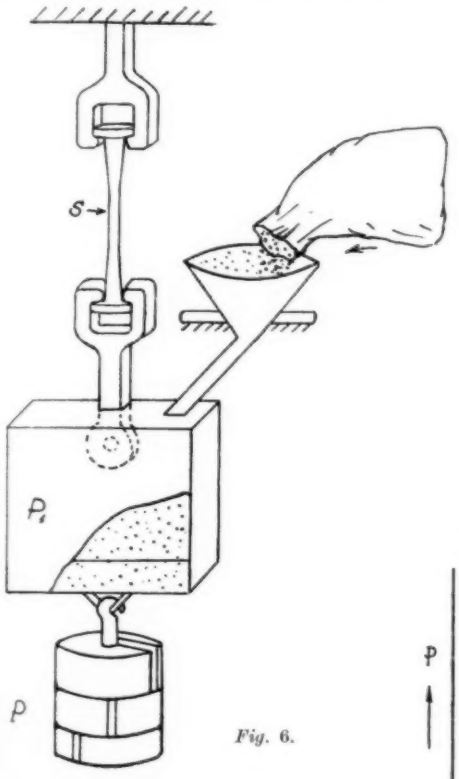


Fig. 6.

and loading spindle, and provided, in addition to constant weights P (Fig. 6) of approximately 200 kilos., also with a container P_1, into which lead shot was poured steadily and regularly with a view to enhancing the direct weight-load until the yield-point and breaking-strain were reached. The further equipment of the machine was in both cases exactly the same The loading process likewise was as far as possible identical with and without direct-weight loading—that is to say, the loading period until the yield-point was reached and thence to the breaking-point was in both cases taken as far as possible of equal duration. These periods tallied with the loading speed of a normal tensile test—that is, the test duration was approximately 3–5 mins.

The loads P, as a function of the travel of the upper clamping head of the machine which transmits the load to the dynamometer and provides a characteristic feature of all tensile machines, are depicted in Fig. 7. This illustration shows that for a travel of the upper clamping head, which transmits the force, of but 1·1 mm., the load indicator of the 5-ton Amsler tensile machine (set for a maximum breaking effort of 500 kilos) drops from 500 kg. to 0 kg. The same as most tensile machines of the kind, the machine has a very great ratio of transmission, in so far as a small vertical motion of the upper clamping head will entail a comparatively large drop of load shown by the dynamometer. For example, when the test-bar lengthens by as little as 0·1 mm. between the clamping heads under a load of 300 kilos., the load indicator, and hence the actual load, will drop to approximately 250 kilos. With direct weight-loading, of course, such a drop in load cannot occur.

Most tensile-test machines available to-day in test laboratories present similar characteristic features in this respect. In addition to the 5-ton Amsler machine, a second machine was used to confirm the viewpoints postulated, having a ratio of transmission between load P and the travel range S of the clamping head which was materially different—viz., which was about in the proportion of 1 in 40 to the first machine. This machine was a small vertical Amsler sheet testing machine of the

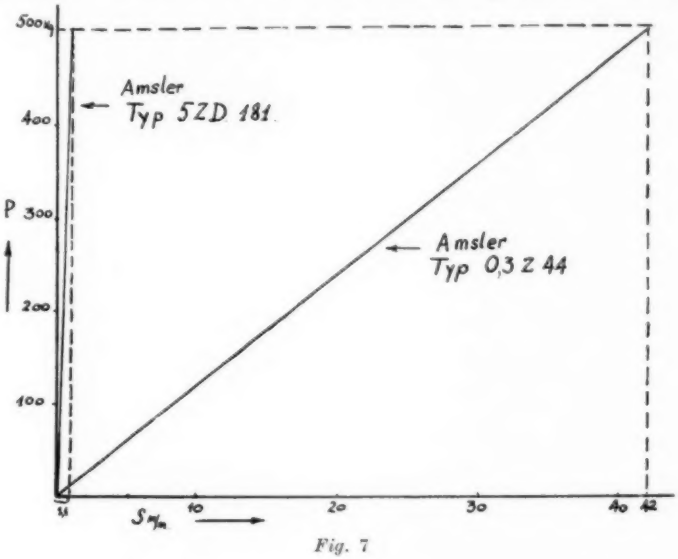


Fig. 7

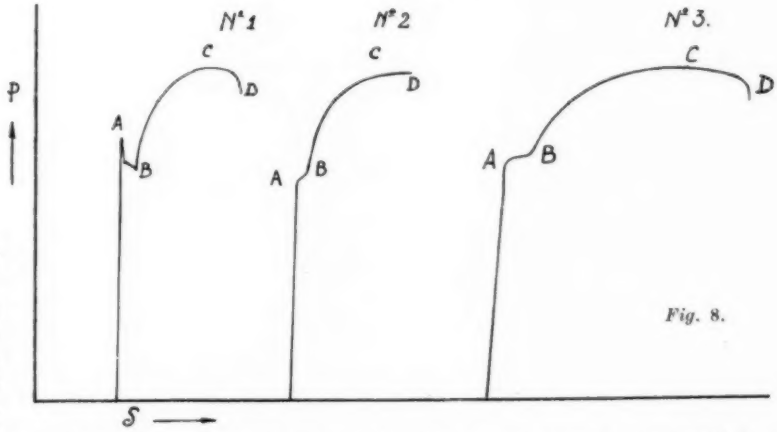


Fig. 8.

0·3 Z 44 type, designed for a maximum load of 500 kilos., with pendulum load indicator. The characteristic load-path diagram of this machine is also reproduced in Fig. 7. It will be seen from this that the load will only drop, assuming the test-bar to elongate likewise by 0·1 mm. under a load of 300 kilos., to approximately 299 kilos.—that is, by approximately 1 kg. With a steady, uniform weight loading amounting to approximately several kilos. per second, a sudden drop in load, due to instantaneous elongation of the rod at the yield-point within approximately 0·1 mm. will no longer be reflected in the diagram, and this, moreover, has been confirmed by the tests.

Test Results

The test results for the long test-bars of a measured length of 65 mm. are reproduced in Fig. 8. It represents tension-elongation diagrams as recorded by the tensile machines for the three different kinds of loading and elongation. Diagram 1 represents the normal known standard diagram for the material tested with a distinct upper and lower yield limit at A—B, which, after reaching

the maximum load at C, shows a steep drop in load prior to breakage of the tests at D.

In contradistinction, Diagram 2, the course of which had been foreseen by the above considerations, shows the actual tension-elongation diagram tallying with actual conditions. This diagram was obtained by direct weight loading of the test-piece fixed in the 5-ton tensile machine. The remarkable fact may be recorded in this connection that in this case there is no upper or lower yield limit to be recorded at all. The material begins to elongate more rapidly at A—B and adopts a course deviating from the degree of load. It is important for the demonstration under consideration, however, that the load between A and B does not decline. On the contrary—and this should be emphasised particularly—the load rises during the yielding interval, even though little, yet steadily and uniformly.

This should serve to prove the first point of our above contentions that there is no upper yield limit for mild steel and that the yielding of the material in the ordinary tensile test may take place without drop in load and only under increasing load. The somewhat shorter total elongation at the yield point in comparison with Graph No. 1, where very severe fluctuations in load occur, should be attributable to the course of stresses which in this case is considerably more quiet and steady. Furthermore, the interesting and likewise foreseen fact may be elicited, that on reaching the maximum load at C there is no drop whatever in the load ; the diagram continues to the point D—that is, up to fracture of the test-bar—on approximately the same level. When the test-piece breaks at D, the tensile diagram also comes to an end without reduction in load. On the contrary, here again a very slight rise of D as compared with C occurs, but owing to the local elongation process which develops fairly speedily, this is only vaguely indicated by the contraction. At all events—and it is important to realise this fact—contrary to the normal tension-elongation diagram, there is no drop of load shortly before the breaking of the test-piece.

The third diagram recorded by the small 500-kilo Amsler pendulum machine with small ratio of transmission also shows the characteristic course of the yield limit of A—B just described, which consists of a steady rise in load with a rapid increase in elongation. This part of the diagram, owing to the larger diagram scale of this machine, is very distinct for the elongation, and speaks clearly for the viewpoints put forward—viz., that contrary to our present-day conceptions there is no upper or lower yield limit at all.

For the remaining section of the diagram from C—D, however, the ratio of the machine according to Fig. 7 is still too great to allow of the heavy local elongation, which occurs almost instantaneously, to show no drop of load in the diagram ; the tension drop at C—D is therefore here again in evidence, similar to Diagram No. 1. All the tensile diagrams showing such a decline in load are not true to reality ; the deceptive drop in load is solely attributable to the design of the tensile machine.

The results obtained with the short test-bars are similar to those obtained from the long bars. The tensile diagrams corresponding to the test-pieces, 15 mm. in length, are reproduced in Fig. 9. Diagram No. 1 shows a standard diagram recorded by the usual type of machine, with upper and lower yield limits at A and B ; here again a distinct drop in load is shown after passing the maximum load from C to D. Curve No. 2 represents the diagram for the same material, materially corrected by direct weight-loading, which does not show any kind of load drop either at the yield limit A—B nor within the vicinity of the maximum load at C—D. Here again it is evident how the strain increases steadily—viz., both at the yield limit and also at the breaking point. The material thus shows no upper or lower yield limit, nor any kind of drop in load shortly before the breaking process. Furthermore, Diagram 3 recorded by the small Amsler machine shows a very clear increase in load at the yield limit A—B, while owing to insufficient transmission ratio it still shows a drop in load shortly before the breakage at C—D.

Conclusions

It is fairly evident from the considerations and test results before us that the tension-elongation diagrams recorded by the customary tensile-test machines for soft materials do not in most cases tally with the real properties of the materials. It is more especially the yield-point which calls for correction. The results show that there is no upper or lower yield limit for mild steel (other materials having similar characteristics will give similar results). The upper yield-point is contingent on the design of the test machines. Therefore the conceptions and theories attached to the upper and lower yield limits are practically untenable, because the upper yield-point is an imaginary idea entailed by the misleading features of the tensile machine design. On the contrary, even with a rapidly increasing elongation, the yield limit will increase steadily and regularly.

Furthermore, it has been ascertained that the maximum load limit must tally with the breaking strength of the test-pieces, and that here again no drop in load is to be recorded.

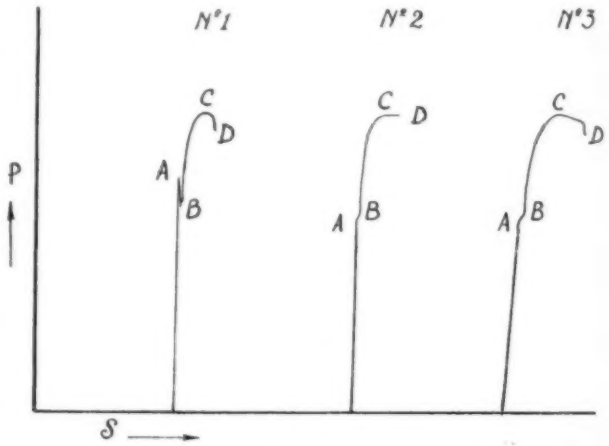


Fig. 9.

The effective resistance values of all materials with a contraction as calculated from the usual tensile diagram, call for some rectification in so far as they are higher throughout than the actual effective tensile resistance values of these materials as determined. These values are thus brought somewhat closer to the theoretically calculated absolute tensile resistance values. Apart from this, the so-called integral degree of the materials calculated from the total area of the tensile diagram is changed materially, and this more particularly with hot tensile tests, where frequently a severe drop of load is observed prior to breaking, due to marked contraction.

Furthermore, it is evident from this study that the tensile testing machines require fundamental reconstruction in order to tally with respect to the recording of the tension-elongation diagrams as far as possible with those operated with a direct-weight load. Machines showing none, or only quite an insignificant drop in load against a sudden elongation of the test-bar, while a detrimental effect of the contra-masses must be eliminated as far as possible, approach these conditions more closely. By means of a comparatively large travel track of the upper, practically fixed clamping head connected with the load indicator up to maximum load, and possibly by interposing a very flexible element between the moving clamping head and the loading device on the machine, these conditions should be fully attained in practice, without being able altogether to supplant the action of machines with direct weight-loading (lead shot or water), which represent the ideal design in this respect.

Note.—This work was carried out at the Laboratory of the Faculty for Metallurgy and Metallography of the Warsaw Technical High School.

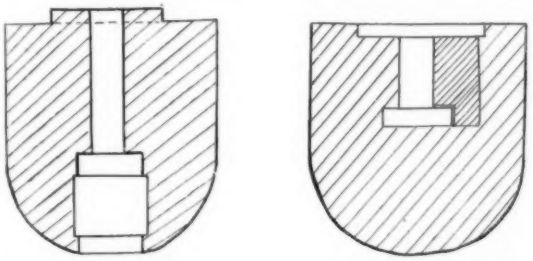
Steel Ladle Refractories

By A. JACKSON

Much may happen to molten steel during its transport from the furnace to the ingot mould, and of the many factors involved, the refractory materials used in the ladle are not the least important in their influence on the quality of steel. Refractories are required to withstand several distructive influences, which are discussed in this article.

IN a ladle used for casting steel, one has refractory materials of at least three types, the lining bricks, the rod covers or stopper sleeves and the stopper end, the pot being often of similar material to the stopper end. One may have further, a graphite stopper end, a part-magnesite nozzle, brick insulation, more than one type of lining brick, jointing compounds and so on.

Each type of refractory has to withstand the effect of several destructive influences of such varying character, that it is impossible to produce a material having maximum resistance to all of them. As a consequence, bricks must be produced which resist all tendencies to destruction to an average amount and so give the longest life in service, and this question of the production of ladle bricks in particular, becomes so nicely balanced that one plant will achieve excellent results, whilst another, using the same brick will have some destructive agency slightly preponderating, so that the brick life will be poor by comparison.



Pot for through bolt. *Pot with loose piece for insertion of bolt.*

Fig. 1.—Two types of stoppers.

The stopper consists of an iron rod, covered with fireclay-rod-covers and terminating at the bottom in a stopper end which is so shaped as to bed on the upper face of the nozzle and form a metal-tight joint. Fig. 1 shows two types.

After fixing the stopper-end, fireclay sleeves up to 15 in. long are threaded on the rod, and the joints "daubed" lightly with clay or well-ground ganister. The cavity between the inside of the sleeve and the rod is often filled with dry sand, though this is normally unnecessary. The male and female ends of the sleeves are generally one of the shapes shown in Fig. 2. If the nib and socket of the joint are not of equal depths it appears better if they are as shown at (*a*) than as (*b*) Fig. 3. They are then much less likely to allow steel through the joint, and so cut the rod in two during teeming. It is seldom that the rod covers are all the same size. In most practice the bottom sleeve is of larger diameter than the centre ones, whilst in plants in which slag is run into the ladle, then over the lip, it is good practice again to have one or two thicker sleeves in the slag at the top, and so counteract slag erosion, whilst the ladle is still under the furnace and the slag very hot. The stopper sleeves should not be fastened tightly on the rod in such a way that vertical expansion cannot take place whilst the ladle is being filled, or the stopper will almost certainly break down or the end be forced off.

Rod covers are used once only, therefore the question of rate of wear is usually of small importance. The main requirement is that the material shall be capable of considerable resistance to thermal shock, as its temperature will normally be raised many hundreds of degrees in a very short time. To meet this requirement a fairly coarse-grained, lightly-burned material appears best, and low-free silica in the clay appears to have some advantage. It will not have a high resistance to slag attack.

The stopper-end, used to control the stream, requires considerably different properties. It must be highly refractory and resist abrasion, whilst still having a fair resistance to thermal shock. To this end a good clay, well bonded and of low porosity is burned to a high temperature. De-airing of the clay appears to produce an article with the above properties, and having a resistance to thermal spalling above the average.

A ladle may have two stoppers and nozzles, used simultaneously, an arrangement used in many plants. It has many advantages, a few of which are :—

(*a*) The ladle is emptied more quickly, therefore casting plant is in use less time per furnace.

(*b*) Less heat is lost, and less skull results.

(*c*) Slower teeming of ingots is easily attainable, as the pots do not wear much and the ladle head rapidly diminishes. This gives less defective material in the mills due to cracking.

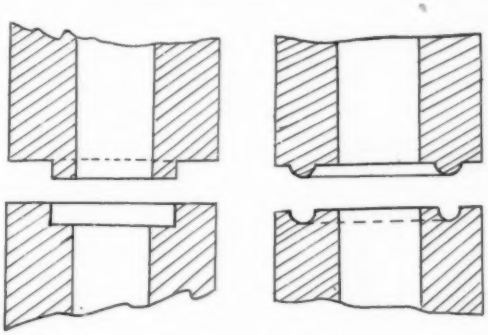


Fig. 2.—Two junction shapes of sleeves.

(*d*) The reduced ladle head is less liable to give splashed ingots when opening the stopper over a fresh mould.

(*e*) With rimming steels, thicker rims result from slower teeming.

(*f*) Better ladle lives may result, due to less destruction by skull drawing.

(*g*) The less average head of steel is less likely to damage the mould bottom plates.

(*h*) In the event of one stopper failing to open, the other may easily serve to get the steel from the ladle.

Amongst the disadvantages are :—

(*a*) More teemers are required.

(*b*) More work in setting up the stoppers and pots, also extra cost of materials.

(*c*) If used for uprun teeming one stopper is normally wasted, as it is so seldom that the second one can be brought into use after the first has failed, that it is not worth the cost of setting up for two.

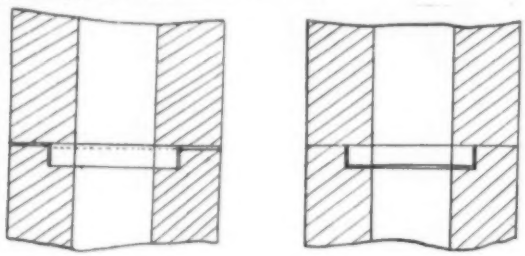
The brick lining of the ladle is usually in two parts, a safety lining in contact with the shell, which should remain in position for many months, and an inner-working lining, which is much more frequently renewed as required. Occasionally no safety lining is used, but this usually occurs when furnace capacity has been increased to increase output, and the ladles which normally had a safety lining are used without, to enable them to hold the increased quantity

of steel. The safety lining varies from one to three inches in thickness, the thicker being advantageous if the ladle capacity is sufficient, it being a sounder job and much less liable to fall out when removing the working lining.

Insulation in steel ladles is not satisfactory for several reasons, as, first of all the ladle is almost empty before appreciable heat has travelled through the firebricks, and secondly, the insulation, even when of a flexible character, soon crushes to powder under the repeated expansion and contraction of the working lining in use. This loose material then falls out during stripping for relining, unless the insulation is held in place by an intermediate lining. This cannot be done on many plants, as it considerably reduces ladle capacity. Insulation on the whole is not a success.

In the working lining the bricks fail due to the combined effects of many factors, some of which are enumerated :—

(*a*) Fluxing by substances in the steel (mainly oxides).
(*b*) Fluxing by the slag.
(*c*) Pure melting, due to heat alone.
(*d*) Mechanical breakage, due to drawing of skulls.
(*e*) Abrasion, due to the stream of steel striking the ladle lining during filling.
(*f*) Spalling, due to thermal shock when filling.
(*g*) Slagging at joints or cracks.



a. *b.*

Fig. 3.—Showing joint when nib and socket are not equal in length.

The amount of fluxing by oxides in the steel depends on the class of material being made, being much greater with oxidised rimming steels, than killed carbon steels.

Fluxing by the slag is mainly due to the lime, or the oxide it contains. A good thick limey slag has far less action on the lining than a thinner and more oxidising one, whilst the high oxide, basic slags produced when making ingot iron, etc., have a most intense destructive action on thet brick lining.

The pure melting action is best resisted by a highly refractory brick of good thermal conductivity, so that heat is rapidly conducted from the brick face. This has the disadvantage that if the " heat " is rather low, excessive skulling may result, with a possibility of consequent destructive action when drawing.

The mechanical breakage due to skulling may again vary. Two types of skull occur :—

(*a*) A thin one with oxidised steels, which " bites " into the brickwork and breaks it badly when drawing.

(*b*) A thick skull, resulting from a dull heat, which shrinks well on cooling and draws easily, with little damage to the ladle.

Abrasion due to the striking action of the liquid steel is difficult to avoid and always results in one part of a lining wearing out before the rest. It can be avoided to some extent by causing the metal stream to fall into or near the ladle centre, once some depth of metal is present, also by careful design of the lander end. In many plants abrasion does much to determine the ladle life.

The above destructive tendencies are probably best resisted by a dense well-burned refractory of a luminous type.

Thermal spalling may occur with a dense brick if strongly vitrified, also it is very liable to occur with a black heart brick—in either case the cracks and broken corners slag easily and given a short ladle life.

Circular ladles give better lives than oval shapes, and allow the use of side-wedge bricks, shaped to fit the sweep of the ladle. The bonding may be clay or siliceous material. Clay should be in the form of a slurry and the joints should be as thin as possible. Siliceous (ganister) jointing may be thicker. It has an advantage over clay in that it expands with heating, whereas clay contracts, and this makes up for any slight tendency of the siliceous material to flux the adjacent brickwork. When clay bonding is used, it should contain plenty of " grog " and so reduce the contraction on heating. Bad jointing ruins the ladle life as slagging of the brickwork always starts at the joints.

Badly burned bricks with a black heart, may produce internal melt, and the surface comes away in large pieces.

Before receiving the cast of steel, the ladle should be clean, dry, warm and free from slag from previous casts, or loose material left behind from pot ramming and lining patching. Slag from a previous cast, if left in the ladle may remelt and give rephosphorisation of the metal, whilst loose clayey or siliceous matter may be partially retained by the steel as non-metallic inclusions. Non-metallics from the refractories are far more likely to stay in the steel when left in the ladle bottom, or from dirty moulds and runners than when melted from the ladle bricks, these latter being probably detached in sufficiently large pieces to rapidly rise to the top of the steel.

In conclusion, regarding ladle life, figures given by various plants must always be qualified for comparative purposes. The number of casts per lining is influenced by the following :—

(*a*) Type of steel being made.
(*b*) Slag on ladle (gives reduction of life due to fluxing).
(*c*) Thickness of lining.
(*d*) Amount of patching between heats and this has two big disadvantages (*a*) the cost of repeated patching may become greater per ton of steel than more frequent relining (*b*) it undoubtedly tends to produce dirty steel.

The cost of ladle refractories per ton of steel is only a few pence, in consequence, it is difficult to effect considerable savings. These savings must often be balanced against other plant conditions where greater savings may be made to balance more costly ladle practice. A particular and common instance is in fixed-furnace practice, where baths have been enlarged, in consequence ladle linings are reduced below their most economic thickness to enable them to contain this extra steel.

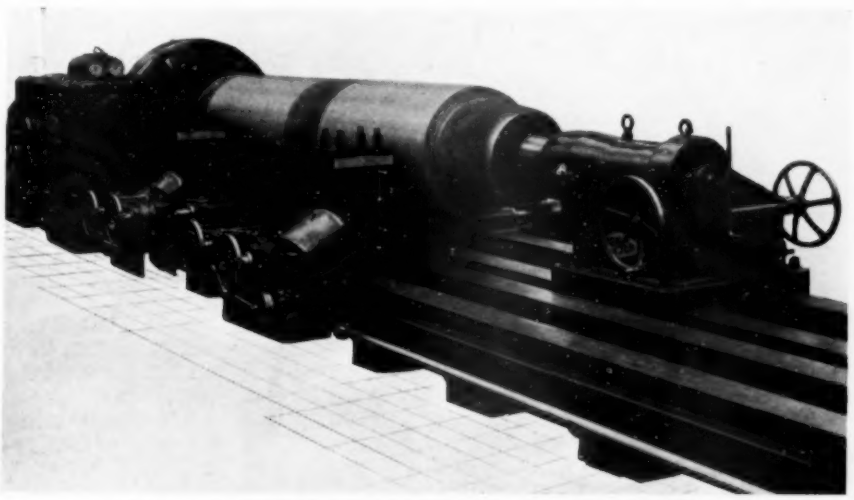
Canada's Geological Survey

It is still too early even to summarise the results of the extensive survey programme in progress in Canada. Enough is known, however, to satisfy the Department of Mines that the expenditure on geological surveys was entirely justified. For instance, the reconnaissance project covering 10,000 square miles of the Yellowknife River district (Northwest Territories) disclosed that approximately 30% of this area (or 2,900 square miles) could be classified as favourable gold-prospecting country. Again, one of the Manitoba projects indicated 200 square miles likely to be favourable for gold occurrences, whilst unprospected areas with similar possibilities were disclosed in Saskatchewan. In the Cranbrook area, in British Columbia, certain promising Tertiary gold-bearing gravels were examined which have previously had but scant consideration, whilst attention will, as the result of such surveys, be directed to the economic possibilities existing in the vicinity of the main line of the Canadian National Railways in the province. In eastern Canada one of the most interesting attainments, perhaps, was the finding of copper-nickel mineralisation of the Sudbury type in sporadic occurrences covering a distance of 14 miles in an area south-west of Fort William/Port Arthur ; the same project also disclosed some 300 square miles favourable to the occurrence of silver. Surveys in the natural gas/petroleum region of Ontario indicated additional favourable areas in which to drill gas, for which there is already a demand by the companies supplying cities and towns in that part of the province.

Machine Tool Developments

Higher cutting speeds and more frequent use of tougher and harder metals impose higher stresses on many parts of a machine tool, and since reliability is an essential factor alloy steels are now used for those parts which occupy key positions. The modern trend in machine-tool design and construction is indicated by two recent examples.

MANY factors have been operating against what was formerly recognised as standard practice in machine-tool design. The progress made in the development of high-duty alloys and the need for increased speed of production have had a considerable influence on machine-tool practice. They have necessitated considerable research with a view to the improvement of cutting materials, and as a result high-speed steels have been improved and other cutting materials of an exceptional character have been developed. The remarkable progress resulting from the introduction of tungsten carbide and other hard-cutting materials is one of the major achievements in recent years. To-day the hardest and most difficult ferrous and non-ferrous metals and alloys are cut at speeds which were formerly considered impossible, but satisfactory results have only been achieved when the machine tools have been designed to take full advantage of these cutting tools.



30-in. centre heavy lathe for turning and parting heavy ingots and rolls

Higher cutting speeds and the more frequent use of tougher or harder metals and alloys impose much high stresses on many parts of which a machine tool is composed, and, since reliability is an essential factor, alloy steels are now used for those parts which occupy key positions. A wide range of these steels are used including the nickel-steels, molybden-manganese steels, nickel-chromium and nickel-chromium-molybdenum steels. More attention is now given to the castings and in addition to the use of low phosphorus cast irons, small percentages of nickel or molybdenum are frequently included, either with or without small percentages of chromium.

Conditions of service determine the choice, but it must be done with proper consideration of the many factors involved, with the main object in view—reliability. The additional cost is justified because it reduces the possibility of breakdown in the production line, which can be very costly. Modern machine tools are invariably designed to take advantage of metallurgical developments and alloy steels are being increasingly used for this purpose.

While higher cutting speeds have caused the machine-tool designer to give careful thought to stresses set up in a machine, engineering progress has been responsible for machines of new design. The modern trend is toward specialisation and the 30-in. centre-heavy lathe developed by Messrs. Craven Bros., Ltd., Manchester, for turning and parting heavy ingots and rolls, is an example of this. This lathe, which will take work up to 45-ft. diameter and 25-ft. overall length, has two front and two rear saddles, each with ratchet feed motion and being adjustable along the bed by hand and power. The front rests are arranged to pass the tailstock. The headstock is arranged with three changes of gear and 75 h.p. variable speed motor drive.

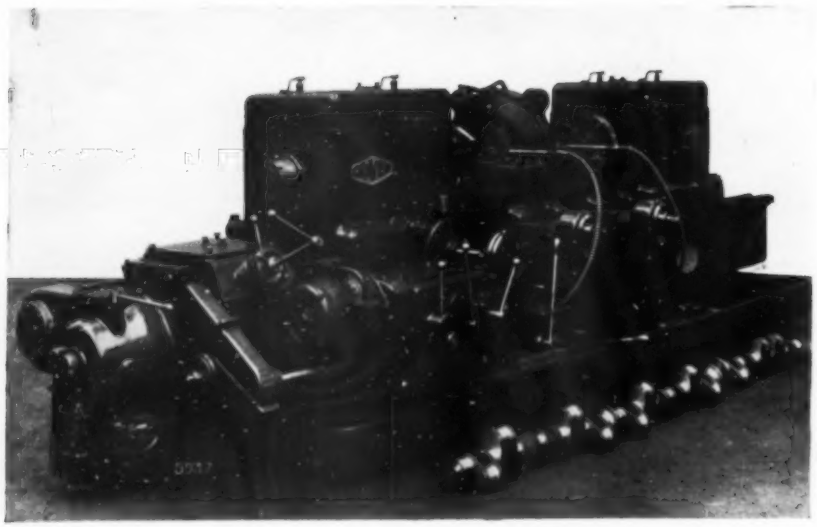
The lathe, shown in Fig. 1, is of heavy construction, capable of taking the heaviest cuts with high-speed steel tools on hard steel rolls, in addition to which the speed range will permit the use of tungsten carbide cutting tools on chilled rolls. The bed is of rigid box section with accurately surfaced square section slides. It is of the four-shear type and is specially designed with cored openings at the base, so that cuttings and chips are easily removable from underneath the machine. The concrete work is also arranged to meet the bed. Tee slots are arranged in the top of the bed for clamping the loose headstock when in position.

The fast headstock is of rigid and substantial construction, the gears being of high-tensile steel, with the speed-change hand wheels conveniently placed at the front for the operator.

Three changes of gear are provided, for use with a 3 to 1 motor. The spindle is of large diameter of high-carbon steel, accurately ground and revolving in phosphor bronze bearings of ample proportions. Ball-thrust bearings are provided to receive end thrust. The final-drive pair of wheels and the faceplate ring and pinion are cut single helical. All shafts carrying sliding gears are splined, whilst all shafts are mounted on ball or roller bearings. The bearings of the spindle are lubricated by means of a small plunger pump, driven from the headstock. Oil cascades over all the gears, the supply being by a motor-driven gear pump.

The saddles and tool slides are of massive construction, the transverse slides being made from semi-steel castings, and the top-tool slides from steel castings. Two saddles are arranged at the front, and two at the rear. The saddles are made right- and left-handed, and each is fitted with compound-tool slides, all slides having suitable adjusting strips for taking up wear. The top-tool slide and the transverse slide are covered by means of telescopic steel-plate covers. The screw in the top rest is arranged with socket type of squares for the handles to operate from either side of the rest. A projection on the front of the transverse slide is arranged so that a prop support for extended tools can be used.

The slides are of the non-swivelling type, and are each arranged with longitudinal and transverse reversible-feed



13¼-in. centre semi-automatic end-driven crankpin turning machine.

traverse and easily operated hand adjustments. The feed is of the variable ratchet type, and the longitudinal traverse takes place through a steel machine-cut rack, arranged behind the front shear of the bed. The transverse traverse takes place through screw and nut. A graduated dial is fixed on the transverse screw for accurate setting of the tool rest. A control lever is conveniently arranged to engage longitudinal or transverse feed as required. A safety slipping clutch is provided in each saddle to prevent damage should the saddles be traversed against any obstruction, whilst a limit switch, controlling the main motor, is fixed on either side of the fast headstock, so that the saddles cannot be traversed up against the headstock, thus obviating any danger of damage to the faceplate jaws.

For controlling the saddle traverse, collector bars are arranged in a covered position at the front and rear of the bed, and contacts are arranged on the saddle for this motor only. For controlling the main motor, start, stop, inch, accelerate and retard buttons are arranged on the headstock, and start- and stop-push buttons are placed at intervals along the front and rear of the bed, so that the operator can control the motor from suitable positions along the bed. The wiring for these buttons is arranged in a tube inside the bed.

Another recently designed machine of unusual interest is the "Craven" 13¼-in. centre semi-automatic end-driven crankpin turning machine, suitable for turning the pins and facing the adjacent webs of six-throw cranks. As will be noted in Fig. 2, the headstocks are totally enclosed, having a box-like appearance, and are provided with power driven revolving spindles of high-carbon steel, revolving in pump-oiled bearings. A large driving gear is arranged on the spindle, driven from a pinion on the main driving shaft. The spindles are arranged with heavy steel supporting and driving brackets, which grip the end journals of the crank as required, and are also provided with means for locating the respective crankpins. The brackets are radially adjustable, allowing for crankpins of varying throws to be accommodated. Both headstocks are adjustable along the bed by rack and pinion for different lengths of cranks, and the right-hand headstock is provided with a quick-power traverse by means of a small motor at the rear of the headstock base.

The tool slides, two front and two rear, of very rigid construction, are arranged in a central position on the bed, the slides being designed to resist the stresses due to intermittent and upward cutting. The front slides are of the flat type, with tee slots to accommodate the tool holders. The rear slides are inclined and arranged for special tool holders in tee slots for rear cutting. They are provided with feeds for facing the webs and also forming the pins, using a broad blade. The front and rear tool slides are fed into the crank simultaneously, and have auto-trip action which maintains accurate diameter without gauging. The feed is arranged to trip automatically from coarse to fine feed for web facing and pin forming respectively, with automatic quick return driven by separate motor at rear of bed. The tool holders are of steel construction, with vertical-formed tools, for the front cutting and broad blades for the rear cutting. The tool holders are quickly adjustable for the varying positions of six-throw crankpins.

The feed motion is driven from the main gearbox through a four-change feed box and control box at the front of the machine. The quick traverse to the tool slides is driven from a small motor at the rear through the control box. This box controls the feed, quick traverse, trip motion and reverse motion to the slides. All the handles are conveniently arranged for the operator. The quick traverse motor also drives a coolant pump of large capacity.

The centre steady stay fitted on the bed between the two pairs of front and rear slides, is fitted with a revolving support disc mounted on a ball bearing and arranged to fit the centre journal of the cranks.

The stay is of the barrow type, to allow the adjacent pins to be machined with the stay in position. The stay is steadied by means of bolts fastened to the left-hand headstock.

The drive to the machine is by constant speed motor, coupled direct to the main gear box by coupling with clutch for starting and brake for stopping the machine quickly. Six changes of speed are provided, the gears are of heat-treated high-tensile steel, totally enclosed and running in oil and the shafts are mounted on ball bearings.

Improved Metal Aeroplane Propeller

Recent experiments with the first three hollow and seamless steel propellers, produced by the Aviakhim Plant in Moscow, have proved the high aerodynamic qualities, increased speed and strength of this new type of aeroplane propeller. Improvement in aeroplane propellers has been lagging behind the general development of aviation technique.

Wood propellers of moderate diameters do not meet any longer the requirements necessary of motors of 800 to 900-h.p. capacity and with 1,800 r.p.m. Consequently, they limit the utilisation of powerful aviation motors on aeroplanes. Another drawback of wood propellers is that they warp from moisture and are easily damaged when stones, balls of snow or even large drops of water get into the area of their rotation.

The problem of replacing wood propellers by metallic ones has long interested aviation engineers the world over. The greater part of the metal propellers used in modern aeroplanes are made of duralumin and have solid blades. They have a higher strength and a higher co-efficient of performance as compared with wood ones. Duralumin propellers are considered to be heavy, and, to some extent, they are subject to corrosion.

The workers of the Aviakhim Plant in Moscow set themselves the problem of designing an all-metal propeller which would be light, strong, of high aerodynamic qualities and resistant to corrosion. Thorough tests of the new propeller were carried out in a special testing laboratory, and aeroplanes fitted with the new propeller during an 11-hour flight proved its high quality. The designer of the new propeller is I. V. Ekk-Ozolin.

THE ORSK COMBINE

Specially Contributed

Remarkable progress is being made in the industrialisation of the U.S.S.R. One of the most important, as well as interesting, recent developments is taking place in the Orsk-Khalilovo district, which is rich in minerals. In this article the author describes briefly the development in this district.

THE neglected little town of Orsk, the " Orsk fortress " of Pushkin's " History of the Pugachev Uprising," is being transformed into a first-class industrial centre. This little backwood settlement in the Orenburg steppe, situated at the confluence of the Ural and Or rivers, has been known only for its past.

Two centuries ago the city of Orenburg was founded here " in order to keep the hordes " of Kazaks and Bashkirians, as the Tsarina Anna Yoannovna wrote in her edict, " in submission and to secure commerce in our interests and in the interest of our subjects." Eight years later Orenburg was built where it now stands. A fortress was built at the estuary of the Or River It was succeeded some time later by the town of Orsk.

Orsk fulfilled its duty as sentry for the East and lost its importance. It was a place of exile for political prisoners in the 19th century. When a certain scientist at the end of last century asked for information on Orsk, the city fathers gave him the following: 12,800 inhabitants, two orthodox churches, a church school, a mosque, a market-place and a hospital with 24 beds.

To-day there is being built near Orsk, 2,000 kilometres from Moscow on the border between Europe and Asia, what Mr. S. M. Frankfurt describes as a " combine of combines." Mr. Frankfurt is the former chief of Kuznetskstroi and the present representative of the Commissariat of Heavy Industry in charge of the Orsk-Khalilovo construction scheme. It is, he says, one of the rarest industrial combines ever created.

Iron Ore Deposits

The Orsk-Khalilovo district has come to be known as the " museum " of all the earth's minerals. Discovered there have been deposits of over a thousand million tons of iron ore, estimated to exceed the total deposits of the Urals. The ore supplies of the district are said to be sufficient to maintain several plants the size of the Kuznetsk Plant and the one at Magnitogorsk. The quality of the ore is just as amazing as its quantity, for it contains 55% of pure iron, nickel and chromium. Iron ore with an admixture of nickel and chromium produces excellent steel. The United States is the only country in the world with a large plant using the same kind of ore as that found in the Orsk-Khalilovo district.

Non-ferrous Ore Deposits

It has been known for a long time that there were deposits of non-ferrous metals in that region. Excavations of ancient Finnish tombs—Finnish tribes lived in the region some 2,000 years ago—revealed not only stone implements, but articles of copper, silver and gold. The Finns smelted their copper with an admixture of tin and produced bronze.

Large copper deposits of great value have recently been found at Bliava, near Orsk. The secret of the Bliava " iron hat " has been exposed. Geologists now know for certain that rich deposits of copper and sulphur lie beneath the layer of iron ore. It has been found, incidentally, that a ton of this copper ore contains 130 grams of silver and 11 grams of gold, while the deposits of nickel ore in this district are known to rival those of Canada.

Other Raw Materials

What are some of the other minerals found in the Orsk-Khalilovo district? There is cobalt, which is used in paints. There are ochre, calcothar, magnesium; there are hundreds of millions of tons of talc, the mineral which is an essential ingredient not only of certain toilet powders, but also of refractory materials used in the metallurgical industry. There are perhaps a thousand million tons of excellent limestone, a massive block of 100 million tons of garnet, and slate of which roofs are made. There are building materials such as refractory clay, quartz sands and crystal slates, and there are asbestos, semi-precious stones, such as topaz, opal and rock crystal, and the finest marble in the world. Since explorations were begun in the Orsk-Khalilovo district only a few years ago, the discovered deposits seem to grow day by day. The new sources of nickel found in the vicinity of the village of Akerman recently, amazed even those who expected riches to be uncovered. There seemed to be no end to the beautiful emerald-green veins of the metal.

Development of the District

The construction of the " combine of combines " based on the natural resources of the Orsk-Khalilovo district, will involve an investment, it is estimated, of 5,000 million roubles, five times as much as the cost of Magnitostroi. Annual investments are planned to reach 500 million roubles. Nearly 150 million roubles were invested in 1935, and twice as much is planned for 1936. Hundreds of trains loaded with timber, iron, cement and other materials will steam into the Orsk-Khalilovo district. Reconstruction of the Orsk railway junction and construction of new railways are problems already being tackled.

The first link of the " combine of combines " was forged on the 18th anniversary of the October Revolution. On that date, the first unit of the Orsk oil refinery was started. A black stream of rich oil flows to the Orsk cracking plant through a huge pipe from Emba. At Orsk the oil will be converted into gasoline, kerosene and various lubricants, and from there it will flow through pipes to the eastern parts of the Soviet Union. Costly methods of transportation will thus be avoided.

The first unit of the cracking plant will turn out half a million oil products annually; when the whole plant is completed it will produce 1.5 million tons. In the meantime plans are afoot to open a central power and heating station at Orsk.

The building site of Bliava spreads over an immense area. Many kilometres of roads have been built, a branch railway has been laid, and a power-station, a sawmill, a number of schools, clubs and stores have been erected. Mines equipped with the latest machinery produce several thousand tons of copper ore daily. Within two years Bliava will have a copper plant capable of turning out 25,000 tons a year. It will then be among the leading copper-producing centres of the world. This plant will lead also in the production of sulphur.

Orsk's splendid locomotive plant has already assumed definite form, its building towering high in the air. It is anticipated that in 1937 the plant will be one of the world's greatest, with its annual output of 540 diesel locomotives and a similar number of steam engines. Orsk's nickel plant, with its 10,000 tons of nickel a year, will be working within a few months. Building is about to be commenced of the metal combine with its auxiliaries of cement, glass, brick and wood-working plants and its machine repair factory. There are 40,000 or more workers already busy

on construction. The number will reach 100,000 when everything is in full swing.

The waters of the Ural, already supplying energy for Magnitogorsk, will be turned also to the service of the Orsk-Khalilovo industrial combine. When the dam for this purpose has been constructed the agricultural map of Orenburg Province will be altered.

The designing of the new city of Orsk has been placed in the hands of engineers of the State Industrial Designing Trust, the Town Planning Institute and the Communist Academy. Most of the new city will lie beyond the present boundaries, the present territory probably being transformed into a children's town. The new city will be built to house a population of 250,000. And so rich is the Orsk-Khalilovo district in building materials of the finest quality that it will not be necessary to transport any from outside. The limestone, sand, diorite, porphyry, marble, quartz, and multicoloured jasper lie right at the city's door. Orsk, the new city, will be constructed of these materials.

Output of Heavy Industry in the U.S.S.R.

A considerable increase in the output of Soviet heavy industry was shown in the figures issued for the first ten months of 1935. Steel production, which equalled 9·6 million tons for the whole of 1934, rose to 10·1 million tons for the first ten months of this year. A corresponding increase was reported in rolled steel—from 6·7 million tons to 7·2 million tons. In pig iron, production has already reached 10·3 million tons as compared with 10·4 million tons for the whole of 1934.

A marked growth was also evident in the production of harvesters, 19,570 having been turned out in the first ten months of this year, as against 8,289 for the whole of 1934. The output of freight cars for the Commissariat of Railways rose from 29,443 (1934) to 73,755 in the ten months of 1935.

Production of copper and aluminium has also substantially exceeded the level of 1934. In contrast to last year's entire output of 53,600 tons of copper and 14,400 tons of aluminium, the output for the first ten months of 1935 reached 62,300 tons and 19,900 tons respectively.

With production figures of 1,278 locomotives and 62,159 trucks, heavy industry has also surpassed in these fields the output of 1934. A 14·1% increase is reported in the coal mined during the first ten months of the year, as compared with the whole of 1934. In October, the coal output increased by 26,350 tons, as compared with September.

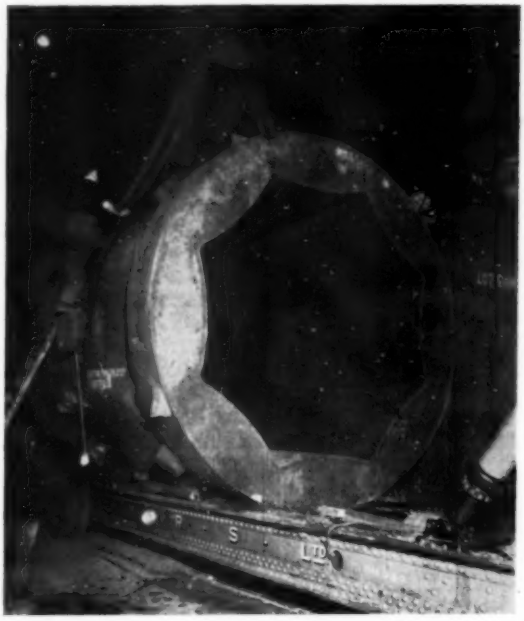
Hudson Bay Mining and Smelting Co., Ltd.

The Hudson Bay Mining and Smelting Co., Ltd., which is developing an important zinc-copper-gold orebody at the Flin Flon mine on the Manitoba-Saskatchewan border, is expected shortly to expand its average extraction as the result of the installation of three-ball mills, by which mill-feed will be ground finer. No enlargement of ore tonnage treated is contemplated, but the new methods are expected to increase the average recovery of metal, more particularly gold and copper. The Company's products already include copper, zinc, gold, silver, and selenium, and cadmium is to be added shortly. For some time past cadmium precipitate has been stock-piled, and at the beginning of the year there were on hand 5,495 tons, running 3·63% cd., 6·76% cu. and 55% zn. The recovery of gold and silver last year reached between 70 and 75% of the total content, whilst that of silver and zinc was something less. The ore has always been recognised as an extremely complex and difficult one to treat. The new arrangements will handle stocks on hand as well as the current supply of precipitate.

The ore position of the mine is understood to be very satisfactory, the amount in reserve being well maintained. Next year the underground mine will take on the full burden of supplying ore to the production plants, as the economic limit of the open-pit (which now provides 60% of the tonnage) will probably have been reached.

World's Largest Ingot Mould

The record for the largest steel ingot ever made in this country is held by the English Steel Corporation, Ltd., Sheffield, the ingot weighing 175 tons. This record is now to be broken as the English Steel Corporation are being called upon to make forgings which will require ingots well over 200 tons in weight.



Arranging the slings to lift the ingot mould from the motor-lorry at the Vickers Works of the English Steel Corporation, Ltd.

The mould, claimed to be the largest ever made in the world, required for these ingots, which necessitated the use of over 170 tons of molten metal, is shown in the accompanying illustration. It was made by the Brightside Foundry and Engineering Co., Ltd., at their Brightside Works, and was delivered by means of a large motor-lorry, claimed to be the largest in the world, to the Vickers Works of the English Steel Corporation, Ltd.

Catalogues and Other Publications

Barrow Hæmatite Steel Co., Ltd., have issued a booklet giving full information regarding their products. Included is a diary and memoranda for 1936. The booklet is presented in a useful form, copies of which are obtainable from the Head Office and Works, Barrow-in-Furness, Lancashire, England.

A new booklet entitled "Castings and Sodium Carbonate" recently published by Imperial Chemical Industries, Ltd., describes how a big engineering firm uses the sodium carbonate process, the adoption of which has resulted in striking improvements in the quality of castings produced. The use of this refining process is described in connection with the production of castings for a 10,000 cu. ft. compressor for a South African mining company. The booklet, which has a foreword by Mr. Vincent C. Faulkner, is remarkably well produced and the illustrations are excellent. Although the use of sodium carbonate is not confined to the iron foundry, its application in this instance is noteworthy. Write for a copy to Imperial Chemical Industries, Ltd., Imperial Chemical House, London, S.W.1.

"Arc Welding on Tramways" is the title of a publication recently issued by Murex Welding Processes, Ltd. Almost every tramway undertaking is in possession of a welding machine, and the technical information given in this publication will be very helpful in its successful use. Copies of this publication are available from Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, London, E.17.

Business Notes and News

Parsons Memorial Lecture

At the invitation of the Royal Society, the Institution will arrange the first of the Annual Lectures to be held in connection with the memorial to the late Hon. Sir Charles A. Parsons, O.M. The Institution has nominated Sir Frank E. Smith, K.C.B., F.R.S., to deliver the Lecture and the Council of the Royal Society have approved of the nomination. The Lecture will be held in Newcastle upon Tyne probably in the latter part of 1936; the date and further particulars will be announced in a later issue. Sir Frank Smith is Secretary of the Royal Society and Secretary of the Department of Scientific and Industrial Research. He was Director of Scientific Research, Admiralty, from 1920 until 1929.

Darlington Forge to Reopen

It has been decided to reopen the Works of the Darlington Forge, Ltd. A start has already been made with work necessary to put the plant and equipment in a state of efficiency. The Darlington Forge, Ltd., which is a subsidiary company of the English Steel Corporation, Ltd., it will be remembered, is associated with many large ships built in the United Kingdom, for which it made the huge sternframes and other castings as well as the rudders, shaft brackets, propeller shafts, etc., and more recently supplied the large structural castings for the *Queen Mary*.

A Large Rolling Mill

The Metropolitan-Vickers Electrical Co., Ltd., have received an important order from the Cargo Fleet Iron Co., Ltd., for the electrical equipment for the new 32-in. reversing universal mill being installed by the above Company at their Middlesbrough Works. The equipment on order comprises the supply and installation of a 15,500 h.p. single armature reversing mill motor, complete with 4,600 k.w. flywheel motor generator set, switch and control gear, and ventilating equipment. The equipment will embody the most recent developments of the Metropolitan-Vickers Electrical Co., in the design of electrical equipment for reversing mill drives.

I.C.I. Board of Directors

At a meeting of the Directors of I.C.I. held on January 9, Mr. H. J. Mitchell was unanimously elected President of the Company in succession to the late Marquis of Reading, and Mr. H. O. Smith, Chairman of I.C.I. (Metals), Ltd., was elected a Director of I.C.I.

Mr. H. J. Mitchell is one of that small and select band who have risen to the highest positions in industry without becoming widely known to the general public. Yet few industrialists of the present day are better equipped or have a wider knowledge and experience of all aspects of trade and commerce. He entered the service of the Nobel-Dynamite Trust on probation in 1893, and by steady advancement reached the position of secretary to the company in 1912. On the outbreak of war he was appointed liquidator of the Trust Company, and carried through the difficult negotiations which led to the final agreement covering the re-organisation, and in 1915 he joined the staff of the re-organised Nobel's Explosives Co., Ltd., as Assistant General Manager at the headquarters of the company in Glasgow.

There then began an even more intimate association with Sir Harry McGowan than had existed in earlier years. The immediate task was to face the problem of munitions supply, in which the company naturally played such an important part, but an equally difficult task lay ahead in the question of what was to happen with the various companies engaged in the explosives and cognate trades when the war ended and competition re-asserted itself. After many months of negotiation, the solution was found in the formation in 1918 of a combination of the explosives and ammunition interests of Great Britain under the name of Explosives Trades, Ltd., later altered to Nobel Industries, Ltd. Sir Harry was appointed the Chairman and Managing Director, and Mr. Mitchell, General Manager. In October, 1920, he joined the Board of Nobel Industries, Ltd., and on the formation of I.C.I. in 1926, in which he took no small part, he was elected one of its original directors. His knowledge has been of the greatest help to Sir Harry McGowan in the solution of the many problems which have from time to time faced I.C.I.

The International Nickel Company of Canada Limited

Increased Smelting Capacity Planned for 1936

The International Nickel Company of Canada has decided to spend $6,000,000 on the enlargement of their smelter at Copper Cliff, Ontario. The completion of this construction programme states the *Northern Miner* (Toronto), will result in the expansion of nickel production facilities in a year's time by from 40%–50%. Additional equipment is also being provided in the flotation end of the concentrator. The Company's production of nickel is stated to be more than treble that recorded three years ago, and the figures relative to world consumption in 1935 promise to be the largest on record, exceeding even those for 1929, amounting to 136,000,000 lbs.

The new programme will add two reverberatory furnaces, making seven in all. Eight new converters will be added to the existing twelve, whilst another three will be installed in the Orford plant for use in the separation of nickel and copper. A new high stack will be built—in this connection it may be recalled that the present stack (510 ft. high) is the highest chimney in the British Empire.

This new $6,000,000 smelter programme follows the capital expenditure amounting to $68,000,000 during the past ten years, during which time the Company has completely modernised its plant in the United States, Canada and Great Britain. Of this $68,000,000 there was spent at Copper Cliff, Port Colborne, or elsewhere in Canada about $62,000,000, the bulk of the expenditure being made in the years 1928, 1929 and 1930. The Company's part interest in the Ontario Copper Refining Company, Limited, was converted last summer into full ownership at a total cost of $11,500,000, and this figure should be added to $56,390,348 paid out by the Company from 1926 onwards on account of mines, smelters, and other properties.

Copper Situation in Canada

Returns for the 10-month period ending October, 1935, definitely indicate that for the third successive year Canada will have established a new record in copper output. Based on these returns the 1935 production is estimated at 215,000 tons, which compares with 182,000 tons in 1934. The Dominion's production in 1935 will account for approximately 15% of the world total for that year, which compares with 5·7% in 1929.

According to the Department of Mines, Ottawa, expenditures in plant expansions, totalling tens of millions of dollars, made prior to and during the earlier years of the depression, have placed Canadian producers in a strategic position to take full advantage of the steadily increasing demand for the metal. The larger companies now have facilities for all stages of operations, from the mining of the ore, to the marketing of the finished product.

Present indications are that 1936 will witness a further expansion in Canadian copper operations, and should the price of copper continue to improve, it is likely that activities will be resumed at several properties which have been idle for years.

As a result of the appointment of Sir Charles W. Craven, O.B.E., as Chairman of the Boards of Vickers-Armstrongs, Ltd., and English Steel Corporation, Ltd., and the decision to reopen the Works of the Darlington Forge, Ltd., it is announced that Mr. Alex. Dunbar and Mr. A. B. Winder have been appointed Joint General Managers of the English Steel Corporation, of Darlington Forge and of Industrial Steels.

Mr. Winder is at present a Director and General Manager of the English Steel Corporation and Industrial Steels. Mr. Dunbar, who is also a Director of the Corporation, holds the position of Commercial Manager.

Foundry Services, Ltd., have sent us a copy of their little bi-monthly publication entitled "Foundry Practice." No. 17 deals with the melting of pure nickel; the application of lithium and calcium as deoxidisers; an alloy suitable for castings used in connection with hydrochloric acid; the influence of lead on brass; and manganese bronzes. This little paper is issued free of charge and intended for the practical man. Copies will be forwarded on application to Foundry Services, Ltd., 285, Long Acre, Nechells, Birmingham, 7.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£73	0	0
Chinese	62	0	0
Crude	32	0	0

BRASS.

Solid Drawn Tubes	lb.	9¼d.
Brazed Tubes	„	11½d.
Rods Drawn	„	8¾d.
Wire	„	7½d.
*Extruded Brass Bars	„	4¼d.

COPPER.

Standard Cash	£34	13	0
Electrolytic	39	0	0
Best Selected	37	15	0
Tough	37	5	0
Sheets	66	0	0
Wire Bars	39	5	0
Ingot Bars	39	5	0
Solid Drawn Tubes	lb.	10½d.	
Brazed Tubes	„	10¼d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	3
‡Ferro Tungsten	„	0	3	0
NOMINAL — Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
2–4% Carbon, scale 11/- per unit	ton	29	15	0
4–6% Carbon, scale 7/- per unit	„	22	7	6
6–8% Carbon, scale 7/- per unit	„	21	12	0
8–10% Carbon, scale 7/- per unit	„	21	12	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33	10	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	5	0
§Guar. max. 0·7% Carbon, scale 12/6 per unit	„	37	5	0
‡Manganese Metal 97–98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25–50%	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	17	6
45/50% basis 45%, scale 5/- per unit	„	12	5	0
70/80% basis 75%, scale 7/- per unit	„	17	17	6
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	12	17	6
§ Ferro - Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	20	0	0
§ Ferro-Molybdenum, Molyte	lb.	0	4	6
§ Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—				
S. Wales	—	1	5	0
Scotland	—	1	8	0
Durham	0 19 0 to	1	2	0
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	—	1	0	0
Durham	—	0	19	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£58	0	0
*Commercial Ingots	42	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 9
*Cored Bars	„	0	0 11

LEAD.

Soft Foreign	£15	7	6
English	17	10	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	10	2	6
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	12	6
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £7 10 0 to	8	0	0
Gas Strip	10	12	6
S. Yorks —			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9¼d.
*Cored Bars	„	11¼d.
†Strip	„	11d.
†Sheet to 10 W.G.	„	11¼d.
†Wire	„	1/0½
†Rods	„	11¼d.
†Tubes	„	1/1½
†Castings	„	1/-

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	13	6
Foundry No. 1	3	16	6
„ No. 3	3	13	0
N.E. Coast—			
Hematite No. 1	3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
„ No. 4	3	9	0
Silicon Iron	3	10	0
Forge	3	9	0
Midlands—			
N. Staffs Forge No. 4	3	11	0
„ Foundry No. 3	3	15	0
Northants—			
Foundry No. 1	3	15	6
Forge No. 4	3	8	6
Foundry No. 3	3	12	6
Derbyshire Forge	3	11	0
„ Foundry No. 1	3	18	0
„ Foundry No. 3	3	15	0
West Coast Hematite	4	6	0
East „ „	3	11	0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron Kr. 105
Billets Kr. 240-310 £12 7 6-£16 0 0
Wire Rods Kr. 290-340 £15 0 0-£17 10 0
Rolled Bars (dead soft)
Kr. 200-220 £10 6 0-£11 7 0
Rolled Charcoal Iron Bars
Kr. 290 15 0 0
All per English ton. f.o.b. Gothenburg.
Converted at £1 = Kr. 19.40 approx.

SCRAP METAL.

Copper Clean	£28	0	0
„ Brazier	25	0	0
„ Wire		—	
Brass	18	0	0
Gun Metal	27	0	0
Zinc	8	0	0
Aluminium Cuttings	74	0	0
Lead	13	10	0
Heavy Steel—			
S. Wales	3	2	6
Scotland	2	12	0
Cleveland	2	15	0
Cast Iron—			
Midlands	2	7	6
S. Wales	2	14	0
Cleveland	2	17	6
Steel Turnings—			
Cleveland	1	17	6
Midlands	1	17	6
Cast Iron Borings—			
Cleveland	1	7	6
Scotland	1	17	6

SPELTER.

G.O.B. Official		—	
Hard	£12	5	0
English	15	10	0
India	13	15	0
Re-melted	13	10	0

STEEL.

Ship, Bridge, and Tank Plates			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „		—	
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester			
Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ¼ in. to ½ in.	„	3d.
Under ½ in. to ⅜ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ½ in.	„	3d.
„ „ ½ in. × ½ in.	„	1/-

TIN.

Standard Cash	£211	10	0
English	211	15	0
Australian	211	10	0
Eastern	208	10	0

Tin Plates I.C. 20 × 14 box 18/9

ZINC.

English Sheets	£22	10	0
Rods	27	15	0
Battery Plates		—	
Boiler Plates		—	

*McKechnie Brothers, Ltd. Jan. 11 †C. Clifford & Son, Ltd., Jan. 11 ‡ Murex Limited, Jan. 11

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Jan. 11